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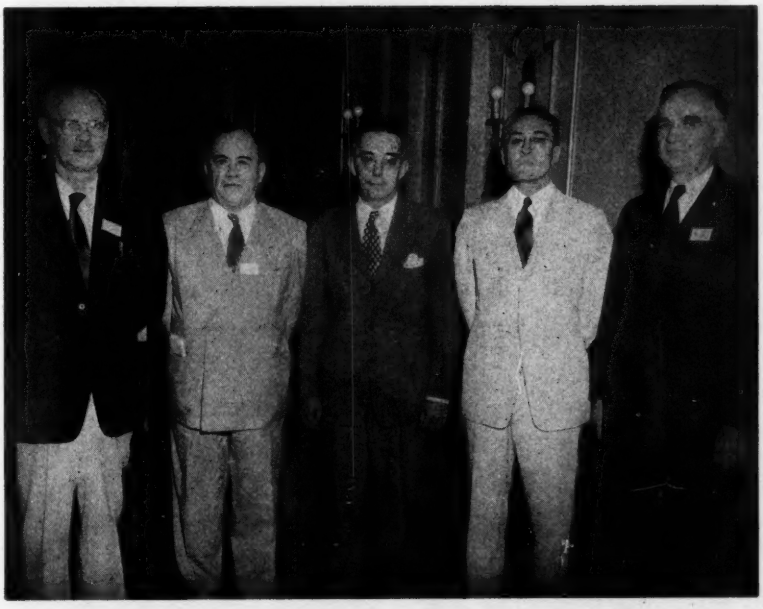
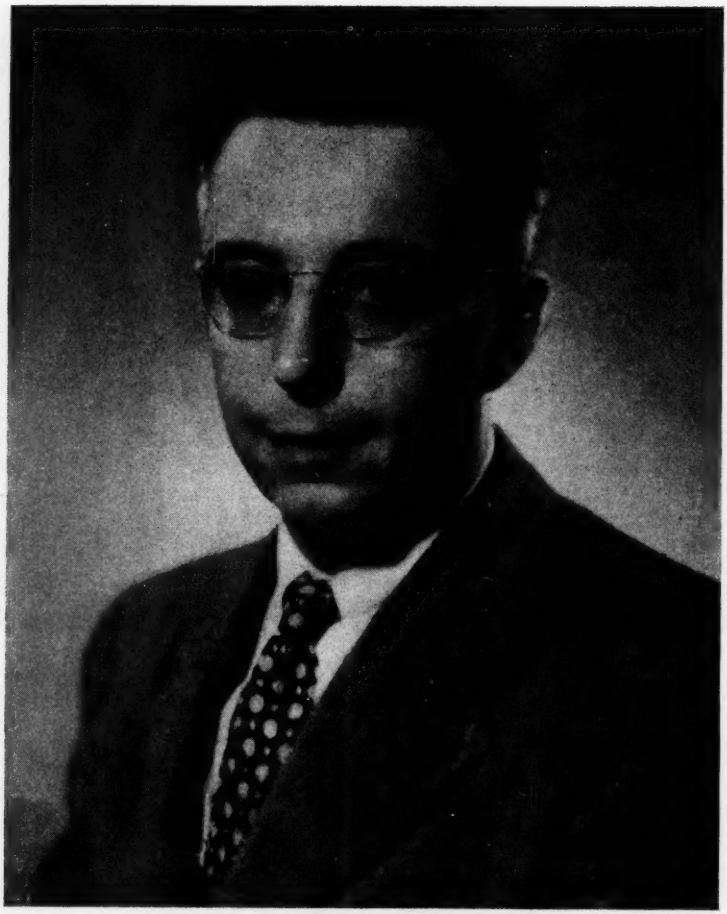


NEW OFFICERS OF THE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Left to right: F. M. Dawson, Dean of the College of Engineering, State University of Iowa, vice-president; E. B. Norris, Dean of engineering, Virginia Polytechnic Institute, vice-president; H. O. Croft, Professor and head of the department of mechanical engineering, State University of Iowa, president; C. J. Freund, Dean of engineering, University of Detroit, vice-president; J. S. Thompson, president of the McGraw-Hill Book Co., New York City, treasurer. J. R. Killian, executive vice-president of the Massachusetts Institute of Technology, is also a vice-president. The appointive secretary of the association is F. L. Bishop, head of the department of physics, University of Pittsburgh.



HUBER O. CROFT, PRESIDENT, 1946–1947

PROFESSOR AND HEAD OF THE DEPARTMENT OF MECHANICAL ENGINEERING,
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Huber O. Croft, President, 1946–47

Huber Ogilvie Croft was born in Denver, Colorado in April, 1896, and attended the grade schools of that city, and graduated from East Denver High School in 1914. He then attended the University of Colorado where he obtained a B.S. degree in mechanical engineering in 1918. After service as a private in the Air Corps he was discharged and entered the employment of Swift and Company as Assistant to the Chief Engineer of the Denver plant. He then became connected with the Stearns-Rogers Manufacturing Company of Denver and later with Durbin Van Law, Consulting Power Plant Engineer.

Professor Croft began his academic career at the University of Illinois in 1922 and obtained his M.S. degree from that institution in 1923, where he remained as an Assistant Professor until 1926. In 1927 Professor Croft went to Stanford University as an Associate Professor, going to the University of Iowa as Professor and Head of Mechanical Engineering in 1929.

Professor Croft is a member of Tau Beta Pi, Sigma Xi, and Pi Tau Sigma and Sigma Chi. He has been very active in the work of the American Society of Mechanical Engineers, having served as Chairman of the Fuels Division, the Committee on Relations with Colleges, and is now on the Nominating Committee of that Society. He was a member of the Council of the Society from 1941 to 1943. He was president of the Iowa Engineering Society in 1939.

Professor Croft is a member of the Iowa City Engineering Club, the American Society of Heating and Ventilating Engineers, the American Rocket Society and the American Society of Naval Engineers.

Professor Croft became a member of the Society in 1930 and served as Chairman of the Mechanical Engineering Division in 1942. He was elected a member of the Council for the term 1944–47.

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Lamme Award—Robert Ernest Doherty

To Robert Ernest Doherty for his understanding of the essentials in engineering achievement; for his demonstration of their significance through his own accomplishments; for his influence upon their recognition in industry and engineering education; for his own devotion to the public responsibilities of the engineer, and his inspiration of others to undertake them.

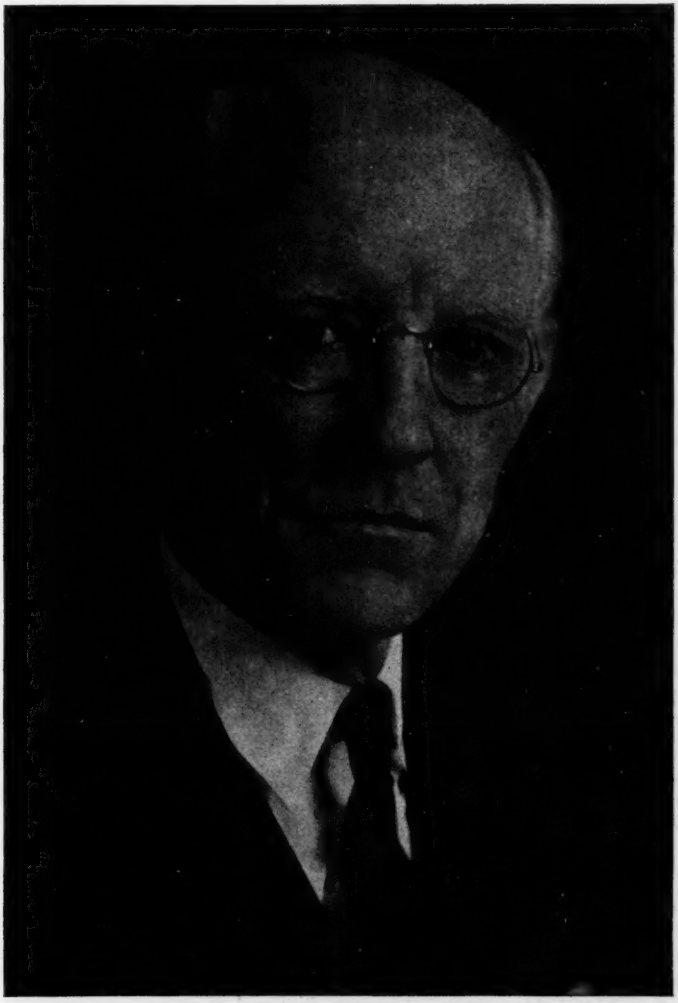
ROBERT ERNEST DOHERTY, nineteenth Lamme medalist of the Society for the Promotion of Engineering Education, was born in Clay City, Illinois, on January 22, 1885. He was graduated from the University of Illinois with the degree of Bachelor of Science in Electrical Engineering in 1909 and received the M.S. degree from Union College in 1921. The honorary degree of Master of Arts was bestowed upon him by Yale University in 1931 and that of Doctor of Laws by Tufts College and the University of Pittsburgh in 1936.

Before entering college, Dr. Doherty worked as a telegraph operator with the Baltimore and Ohio Railroad. Employed by the General Electric Company after graduation, he served as test engineer from 1909 to 1910, as design engineer from 1910 to 1918, and as assistant to Dr. Charles P. Steinmetz from 1918 to 1923. At that time, he was appointed consulting engineer of the company and while serving in that capacity until 1931, he instituted and devoted much of his time to the company's advanced training course for young engineers.

In 1931, Dr. Doherty was appointed professor of electrical engineering at Yale University and in 1933 he also became dean of the School of Engineering there. He was elected president of the Carnegie Institute of Technology in 1936 and now holds that position.

Much of the record of President Doherty's engineering achievements is contained in a series of papers by himself and his associates, largely presented to the American Institute of Electrical Engineers during the period 1918 to 1930. These dealt principally with the design and performance of synchronous machines and with related problems. Stemming from his comprehensive understanding of general principles, these papers set forth simplified methods of attack on complex problems, added to the theory applicable to them, and, more important, cleared the way for further extensions of fundamental theory. His value as a consulting engineer, frequently called upon by other departments, was mainly due to the methods he employed for the solution of problems in his own field. For his individual contributions and the leadership he provided to others in the engineering profession, President Doherty received the Lamme award of the A.I.E.E. in 1937.

In the Advanced Course in Engineering at the General Electric Company, as in his own work, Dr. Doherty laid emphasis on explicit statement of the problem to be solved, determination of the basic scientific principles in-



ROBERT ERNEST DOHERTY

NINETEENTH RECIPIENT OF LAMME AWARD

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volved, and thoughtful consideration of the conditions to be satisfied in the solution. In this course, he laid the foundation for his constantly increasing influence upon engineering education, which has been made manifest not only in the institutions he has served but in his outstanding contributions to the Society for the Promotion of Engineering Education; in 1939–40 as a member of the Committee on Aims and Scope of Engineering Education, in 1943–44 as a member of the Committee on Engineering Education after the War and in the same year, as President of the Society. Since 1944, he has been chairman of its Drafting Committee for Revision of the Constitution.

President Doherty's interest in engineering as a profession, in its effective contribution to the nation, and in the responsibility of engineering education to that end has been demonstrated often in his addresses and through his work with the Engineers Council for Professional Development as Vice-Chairman from 1938 to 1940, member of the Committee on Engineering Schools 1939–40 and Chairman of the Council from 1941 to 1943.

His own civic activities have been constant and important. In 1922, he served as mayor of Scotia, New York and from 1925 to 1929 as a member of its board of education. From 1938 to 1941 he was a member of the Housing Authority of Pittsburgh and he is now chairman of the Allegheny Conference on Community Development, a citizens' cooperative enterprise which works through local, county, and state agencies to develop an over-all plan for the area involving 126 communities.

During the national emergency, he served the Federal Government as chairman of the Production Planning Board of the Office of Production Management in 1941, as member of the National Advisory Committee on Aeronautics, 1940–41, as member of the National Advisory Committee, Engineering, Science and Management War Training, as expert in the Army Specialized Training Division, War Department, as member of the Civilian Advisory Council to the Military Training Service of the Ordnance Department and as chairman of the Consultative Committee on Engineering, War Manpower Commission.

His publications include "Mathematics of Modern Engineering," with E. G. Keller (1936), the technical papers to which reference has already been made, and numerous articles on engineering education.

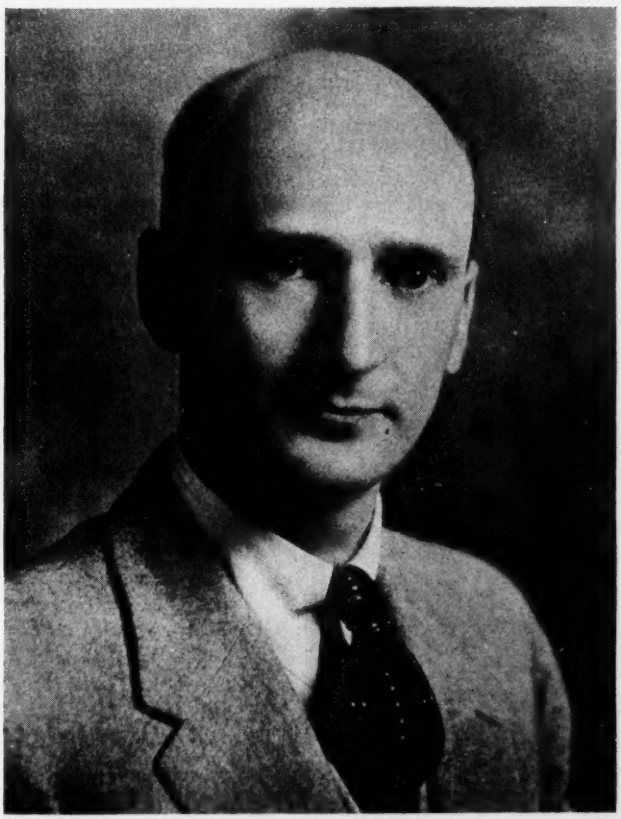
Further evidence of his unusual versatility is given by his skill in music and in painting. He is a member of the Associated Artists of Pittsburgh, and not long ago won first prize in its annual exhibition for a self-portrait.

President Doherty is a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, Theta Delta Chi, Phi Kappa Phi, and Theta Tau. He is a fellow of the American Institute of Electrical Engineers, a member of the American Society of Mechanical Engineers, and a member of the Engineering Institute of Canada. He is also Chairman of the Board, Pittsburgh Branch, Federal Reserve Bank of Cleveland, and a director of the Forbes National Bank and the Montour Railroad.

George Westinghouse Award—James Norman Goodier

To James Norman Goodier—for his work in broadening the scope of sound engineering instruction; for the skill with which he passes on to his students something of his own spirit of pioneering achievement and his high standards of excellence; and for the inspiration his efforts and his example have given to students and co-workers alike, the first George Westinghouse Award in Engineering Education is made.

JAMES NORMAN GOODIER was born in Preston, England, on October 17, 1905. He received his early education in the Preston Municipal Secondary



JAMES NORMAN GOODIER

RECIPIENT OF FIRST GEORGE WESTINGHOUSE AWARD

School and entered Cambridge University at the age of eighteen from which institution he received the B.A., M.A., and Ph.D. degrees. While at Cambridge, Dr. Goodier studied with Professor C. E. Inglis, Professor Horace Lamb, Professor R. V. Southwell, Professor Melville Jones, Mr. W. S. Farran and Mr. E. B. Moullin.

After completing his studies at Cambridge, he was awarded the Commonwealth Fund Fellowship in 1929 and studied at the University of Michigan under Professor S. V. Timoshenko, receiving his Doctor of Science degree from that institution in 1931.

Dr. Goodier was a research fellow at the Ontario Research Foundation from 1931 to 1938. In 1938 he was appointed Acting Professor of Mechanics at Cornell University and became Head of the Department in 1940. He is at present also Head of the Department of Machine Design. He became a citizen of the United States in 1946.

During the war he administered special courses in stress analysis and elastic stability to classes at the Bell Aircraft Corporation and the Curtiss-Wright Airplane Division in Buffalo and directed research work on aeronautical projects at Cornell. In 1945 he was chairman of the Applied Mechanics Division of the American Society of Mechanical Engineers. He is a member of the Society for the Promotion of Engineering Education, American Society of Mechanical Engineers, American Mathematical Society, and the Institute of Aeronautical Sciences.

To the Members of the Society

Another year has ended and those who attended will long remember the Saint Louis meeting both because of the gracious hospitality of Dean Langsdorf and his committee and also because of the great variety and interest of the meetings held. The Saint Louis meeting was a definite milestone in the history of Engineering Education as the constitution for the American Society for Engineering Education was adopted without dissent and our group has "reconverted" for the post-war period.

It is a great experience as well as a great pleasure to welcome all present members of the Society for the Promotion of Engineering Education as "charter" members of the American Society for Engineering Education. The most interesting thing to me is that the name of our group seems inconsequential so long as the same old friends gather together each year to talk shop and tell stories and to discover each year new and younger friends.

Under our new constitution, our diverse activities are now organized functionally under Vice Presidents. Two Vice Presidents to represent individual members (Dean Earle B. Norris, Virginia Polytechnic Institute, to administer the General and Regional activities; and Dean C. J. Freund, University of Detroit, to administer the Instructional Division activities) and two Vice Presidents to represent the institutional members (J. R. Killian, Jr., Vice President of Massachusetts Institute of Technology to administer Engineering College Administrative Council; and Dean F. M. Dawson, State University of Iowa to administer the Engineering College Research Council).

The burden of the work of the American Society for Engineering Education will fall upon these men, Secretary Bishop and the undersigned. Many members of the Society will be asked to help. I hope you will give us your best efforts in order to have a most successful year.

HUBER O. CROFT,
President.

The Threshold of a New Era*

By HARRY S. ROGERS

President of the Society; President, Polytechnic Institute of Brooklyn

Upon an occasion such as this the president of every organization who desires to look into the future is moved to present conclusions which lie somewhere between plain gazing into the crystal ball and the extrapolation of trends as he sees them. Predictions regarding the future in any field of human culture are, however, always hazardous to one's reputation for judgment. In these remarks this morning I shall attempt, therefore, to adhere reasonably close to the processes of extrapolation. To make an extrapolation requires a review of previous history which must inevitably be tied to some system of chronology. It may be related either to the calendar, or to broader periods or eras, characterized by various social and cultural forces and movements.

Probably no two persons of different training, experience and background would classify the major developments in American education in exactly the same manner. Any one who attempts it is therefore under some responsibility to justify his own interpretation. This I shall do as I speak particularly of the certain eras in engineering education within the broader periods of higher education generally. The latter I shall present briefly with very little attempt at documentation or justification, depending upon your own general knowledge of history for its approval.

Colonial and Early American Education

In the Colonial or pre-revolutionary period programs of higher education were influenced and determined largely by classicism, philosophy and religion. The oldest of our institutions, Harvard University, was dedicated "to advance learning and perpetuate it to posterity; dreading to leave an illiterate ministry to churches when our present ministers shall lie in the dust."

In the Early American, or post revolutionary period extending to the time of the Civil War, programs were modified by the secular and scientific point of view, brought primarily from continental universities. Thomas Jefferson and James Madison in 1779 initiated this modification by introducing the scientific and philosophic viewpoint of the European enlightenment into the curriculum of the college of William and Mary. Of this Jefferson wrote: "We secured the abolition of two professorships of Divinity and Oriental Languages and the substitution of a Professor of Law and Police, one of Anatomy, Medicine and Chemistry, and one of Modern Languages; and, the charter confining us to six professorships, we added the Law of Nature and of Nations and Fine Arts to the duties of the Morals Professor and Natural

* Presidential Address, delivered at the 54th annual meeting, Society for the Promotion of Engineering Education, St. Louis, Mo., June 20–23, 1946.

History to the Professor in Mathematics and Natural Philosophy." There is a long and interesting history of this change from the religious and classical to the secular and scientific which I shall not attempt this morning because our interest lies primarily in the third, or Industrial period of American history.

Engineering Education in Industrial Era

It is within this period from the Civil War to the present that engineering education has had its primary growth and development. Certain antecedents of American engineering education are to be found in the Royal Institute of Great Britain founded in 1799 as an offspring of the Society for Improving the Conditions of the Poor, in Fellenberg's School of Hofwill in Switzerland which was founded to "educate the children of the poor," and in some of the earlier schools of France. Benjamin Franklin, sometimes called the father of American education, was advocating a practical form of education as early as revolutionary days. Few colleges of engineering developed, however, in America until the passage of the Morrill Act in 1862, and the early curricula which they presented were modeled after the French Schools of technology.

The curricula in engineering at West Point, Rensselaer, Yale, Harvard, Brown, and Michigan were initiated prior to 1860 but accelerated growth in engineering education began in the decade of the '70s. Within the first two years of this decade the number of schools increased from 17 to 70, and within the next 60 years another 75 schools were added to the list of institutions offering engineering curricula. As of the present we have approximately 167 institutions granting degrees in engineering of which 133 have one or more curricula accredited by the Engineers Council for Professional Development.

The progress of engineering education in this long industrial period may be divided into three eras marked by certain significant and comprehensive characteristics. These may be designated as the formative era from 1862, the date of the Morrill Act, to 1893, the date of founding of this great Society, during which engineering schools were inaugurated and curricula established; the developmental era between 1893 and 1918 during which courses and curricula were expanded and strengthened; and the fundamental and personal era from 1918 to the present during which objectives have been defined in terms of the student's mastery of fundamentals and of his personal development. In each of the last two of these three eras the total enrollments in engineering schools have approximately trebled, attaining a figure of 89,651 in 1943. The number of graduates per million population has increased from 1 in 1860 to 4 in 1880, to 17 in 1900, to 50 in 1920, to 110 in 1940, and to 147 in 1943.

The Formative Era

During the formative era engineering curricula were initiated as variations from the liberal and scientific curricula of the Early American period. Although the first distinct civil engineering curriculum had been offered at Rensselaer in 1829, the time required for its completion was but one year and it was not until 1849 that the time requirement was increased to three. Mining engineering was inaugurated at Columbia University with the establishment of a School of Mines

in 1864, Mechanical Engineering at M.I.T. in 1865, Electrical Engineering at Cornell and M.I.T. between 1880 and '85, and Chemical Engineering at Illinois about 1895. These developments were instituted and directed by educators largely from the departments of physical science and mathematics, and the general academic and basic science subjects predominated in the early curricula. Civil and mechanical engineering based much of their progress upon graphics, mechanics, surveying and shop, but electrical and chemical engineering evolved more directly from courses in physics and chemistry.

Although engineering education was considered academic and abstract, and received little support from the practicing profession, it is interesting to note the evidence of close relationship between the evolving programs in education and the consciousness of the profession as indicated by the establishment of the national engineering societies. The A.S.C.E. for example was founded in 1852, three years after inauguration of the revised civil engineering curriculum at Rensselaer; the A.I.M.E. in 1871, seven years after the establishment of the School of Mines at Columbia; the A.S.M.E. in 1880, fifteen years after the inauguration of mechanical engineering at M.I.T.; the A.I.E.E. in 1884, almost coincident with the development of electrical engineering at Cornell and M.I.T.; and the A.I.C.H.E. in 1908, thirteen years after the inauguration of chemical engineering at Illinois

During this era America was predominantly agricultural and many of the engineering problems were associated with the development of transportation, steam power and steel. Only toward the end was there any significant development of electric power for domestic and industrial uses and for street railway transportation and only at the end was the first American automobile produced. The progress of machine processes was, however, only awaiting the development of high speed steel and direct electrical drive for evolution into mass production industry.

The Developmental Era

One may select 1893 for the beginning of the middle era of development because this is the date of the founding of our Society, because all our major engineering curricula had been inaugurated, with the exception of chemical engineering which was just about to be born, and because only after this date did engineering education win recognition as a distinct and worthy form of higher education. It was only in the nineties for example, that the United States Office of Education in recording the enrollments in higher education began to make any distinction between the differentiated branches of engineering. The World's Columbian Exposition in Chicago at which our Society was born also marks the beginning of an era in which invention and industrial expansion began to command wide interest and receive wide financial support.

In the first presidential address delivered to the Society in 1894, Professor DeVolson Wood made the following comment: "the antagonisms of the past between classical education and scientific education have passed away. There has been a surrender, or truce. Engineering education and abstract scientific education have become closely allied, and technical schools and scientific courses are no longer suppliants for favor at the hands of the traditional educator. Meager preparation and narrow scientific courses of three years,

barely tolerated, have expanded into the technical school with its four or five years course demanding high preparation, well manned with instructors and well endowed with its millions."

The first two committees of the Society were one upon entrance requirements for engineering colleges, and another upon the unification of symbols for engineering text books, and many of the original papers presented before the Society dwelt upon the scope and organization of curricula and courses. Reports made by the early committees foreshadowed some of the forces and developments in the era ahead. The study of the admission requirements made in 1896 and reported in Volume 3 and 4 of the *Proceedings* of the Society showed that, within the more than 100 colleges offering curricula in engineering, there was wide diversity in range and level of admission requirements. There also still remained a wide diversity in the level of training within these institutions. The essential model of engineering curricula had been established, however, by the beginning of the period and no revolutionary change was made during the period although there was increasing emphasis upon engineering technology and upon specialization. Faculty energies were focused upon the organization of courses and methods of instruction in shop, field, laboratory and classroom and upon the building up of equipment and facilities.

The growing demand for engineering was implied in the decline of the agricultural population, the increase in urban population, and the rapid development of manufacturing. In the beginning of the developmental period the total number of associations representing commerce, agriculture and manufacturing was less than 100, but at the end over 1,600, about one-half of which were related to manufacturing. A review of the development of these associations within the period indicates an amazing growth in the number and in the scope of industrial activities and of the firms associated with them.

By the end of the period the advent of electricity, the gasoline engine and the ferro-alloys, together with the development of line production in the automotive field, had given such impetus to the demand for specialization that undergraduate curricula and courses had become widely diversified and well developed. This diversification, however, began to present impossible demands in the variety of courses dealing with the technology of application and brought its logical reaction in the following era by a turn to primary emphasis upon fundamentals.

Fundamental and Personal Education

The era of fundamental and personal education was ushered in following World War I by the publication of a report entitled "The Study of Engineering Education" by C. R. Mann under the auspices of the Carnegie Foundation for the Advancement of Teaching. This report due to conditions following the war, received less than deserved attention from engineering educators. It was, however, very basic in nature and emphasized the need for a return to fundamentals, the development of the student's intellectual capacities, and a discipline in his habits of study and work. Simultaneously, the engineering developments for production required for World War I and the notable contributions made by engineers to its organi-

zation began to stimulate interest in the administrative and humanistic aspects of engineering.

There were, moreover, other forces beginning to bear upon engineering education. I presume some engineering educators would be aghast if one would suggest that they had come under the influence of John Dewey's "pupil centered school" but strangely enough their own interest in students as distinct from subject matter has had its greatest development in parallel with the development of progressive education. Another associated factor which contributed to this emphasis upon personalized education was the development of psychological tests. The relative success of the Alpha Beta tests in the selection and classification of personnel in World War I gave great emphasis to the use of intelligence tests and to testing methods generally throughout industry and in education.

During this period certain industries rapidly adopted analytical methods of selecting employees. The National Association of Employment Managers was organized, and in 1920 incorporated as the Industrial Relations Association of America. The same year, the National Association of Corporation Training was organized and two years later the two merged into the National Personnel Association. In 1923 this association became the American Management Association which has promoted the study and measurement of individual aptitudes, abilities and interests as related to personnel management.

The growing interest in education as such rapidly found its expression within the Society in the demand for sections, branches and divisions which were authorized respectively in 1919, 1921 and 1922; it led to the organization of the Board of Investigation and Coordination in this Society and the studies made under the direction of William E. Wickenden from 1923 to 1929 which were planned by the Board. During the course of this study the Society initiated summer schools for engineering teachers. Shortly after the completion of the study the E.C.P.D. was founded and inaugurated its program of accreditation of engineering colleges.

Later in 1940 a committee of the Society reported upon the "Aims and Scope of Engineering Curricula" and expressed their findings exclusively in terms of skills, abilities, attainments and points of view of the engineering student. And, finally, in 1944 a Committee on Engineering Education After the War reiterated these personalized objectives and elaborated upon the methods of their achievement.

In summary, the development of engineering education has been an orderly, biological evolution. It began as a variant of physical science in the formative era, reached its peak of specialization in the developmental era, and focused its emphasis upon the development of students in the fundamental and personal era. That any period has placed marked accent upon any particular aspect does not, of course, mean that previous objectives and interests have been abandoned, but rather that continuing adjustment to the demands of industry, the profession and society has been made. Today, on the threshold of a new era, there are new accents of need, demand, purpose and objectives that do not supplant but supplement the older ones.

The New Era

World War II brought many new responsibilities to engineering educa-

tors and to engineering schools. Even prior to our entrance into it, the increasing pace of industry created a need for many more engineers than were available and it became necessary to train thousands as aids and technicians through the Defense Training courses. Subsequently the engineering schools were almost depleted of civilian students and simultaneously overwhelmed with training programs for the Army and the Navy.

Together with this the war brought a great demand for research, both in the basic fields of mathematics, physics and chemistry, and in the technological fields of mechanics, aero-dynamics, electronics, metallurgy, aircraft structures, machine design, communications and related devices, recording and measuring devices, servo-mechanisms, and industrial radiology. In some of these fields developments were so new and scientific principles were so specialized that physicists with advanced fundamental training took so much of the initiative from engineers that the war is frequently referred to as a war of physics. While this is not entirely correct, the creative nature of radar and the atomic bomb and the devastating results from their use has overshadowed the engineering developments in ships, tanks, planes and armament which carried destruction to its targets.

The demands for high speed planes, high frequency communications and detecting devices, highpolymers in rubber, in plastics and in textiles, high temperature steel, high tension alloys and high speed production, to name only some, have however, produced corresponding developments in the theory and technology of electronics, metallurgy, applied mechanics and chemical engineering operations and processes. Many fields of technology have been pushed to such levels that one may hardly anticipate advancement to professional competency without graduate training. This would appear to be particularly true in electronics, aircraft design, jet propulsion, metallurgy, applied mechanics and gas turbines. In chemical engineering it was more or less true even before the war. What the impact of the development of nuclear energy will be upon the future of heat power is difficult to predict at the present time.

This presages an expanding demand for engineering education at the graduate level. In this expansion it would appear that education at the Master's level may become even more specialized, while beyond that it will be carried to higher levels in applications of mathematics and of physical sciences based upon a more generic and higher critical understanding.

Some of our institutions are already expanding their offerings at the graduate level and reorganizing their undergraduate curricula for the better support of some of these specialties. New courses in electronics, gas turbines and metallurgy are being organized and advanced curricula in applied mechanics, electronics and aeronautical engineering have been announced.

With vast sums of money available to support research through the Army, the Navy, and the Air Corps, institutions are looking forward to a continuation and a more widely distributed expansion of research paralleling their developments of graduate instruction.

We may expect the advancement of engineering education at the higher levels to move forward more rapidly in the period ahead of us than in any previous time in history.

Training for Citizenship

But what of the broader training for professional advancement and for responsible citizenship? The American people have always held the conviction that the college graduate should at least play a sustaining role in cultural and civic institutions and a discriminate part in politics. Democratic tradition demands participation in civic responsibilities. Industry has criticized engineering education for its laxity in training for leadership and managerial capacities. There is a growing conviction that engineers should play a more intelligent part in the solution of the problems of industrial relations, that they should have a better understanding of human behavior generally and of the impact of technology on society.

We may have inclined to the thought that such criticisms have been leveled primarily at the engineering schools. The current demand for a better understanding of both domestic and world affairs indicates, however, that engineering programs may not have been alone deficient in their preparation for responsible citizenship. The Harvard Report on General Education in a Free Society frankly acknowledges what many of us have long believed, namely that liberal education is a broad program of diversified specialties, little better designed for responsible citizenship than programs of engineering education. Time will not permit a full discussion of this subject but the Report presents a situation which should give pause to those who believe that an extension of engineering education by the addition of standard courses from the departments of liberal arts will make significant contributions to the engineer's preparation for sustaining our social, cultural and political institutions, or for exercising any significant leadership in them. It cannot be denied that any group of courses selected at random from the offerings of the liberal colleges will add to the general culture of the engineer. On the other hand, the current awakening within the liberal arts colleges would indicate there is a great need for a revision of courses and programs that seek to prepare men more directly for responsible citizenship.

Engineering educators can and must play a part in the development of a more rational program, but they can do so only by associating themselves with historians, economists and philosophers. Some of our institutions are already extending their programs to provide broader training. Others will wait until programs directed toward more specific goals can be developed.

A study of personality and of tests for its description has been associated with this broader view of education. The interest in intelligence tests manifested at the beginning of this period as an aid in the selection of students has given birth to a broader and a more critical understanding of selection and guidance. More specific and reliable tests have been developed. Perhaps the best of these is to be found in the pre-engineering inventory which has been designed under the joint auspices of the Carnegie Foundation for the Advancement of Teaching, of this Society and of the E.C.P.D. The program mapped out for the continuance of this work holds considerable promise for the development of tests which will be useful not only for selection and guidance but also for comparative measurements of progress.

The Trend of Developments

What then of the future direction of engineering education in this new era upon whose threshold we now stand? Undergraduate programs will be revised to some extent to meet the scientific and technological developments of the war. Emphasis upon fundamentals and upon student development will continue. Graduate programs and enrollments will expand substantially to encompass the basic scientific and technological developments made during the war. Fundamental research and technological development have and will increase many fold. And engineering educators, still somewhat perplexed, along with their associates in liberal arts, will struggle to adjust their programs so that their graduates may be prepared better for responsible citizenship.

Within this great Society we are organized and prepared for the problems of this new era. Our new Division on Graduate Studies has attacked its problems with enthusiasm, vigor and constructive results. Our new Division on Humanistic-Social Studies has made a notable attack upon the clarification of issues in its field. We are proposing a consolidation of the E.C.R.A. with our Society which should bring the entire weight of the engineering teaching profession behind the development and expansion of research. We are proposing a reorganization of the Administrative Division which should create a more effective instrument for the expression of our points of view in matters of public policy and public relations. Our divisions are vigorously attacking the modification of courses to meet the special problems of interest and concern to the entire membership.

We stand upon the threshold of this new era with clear understanding of our role in science and technology. We are prepared to advance the standards of living throughout the nation by the further development of science and engineering. We are alert to play our part in the protection of democracy and the establishment of peace, but we need a clear understanding and a more specific statement of our goals in general education and in preparation for citizenship. We look forward with the hope that progress in these broader fields of development may be rapidly accelerated.

Minutes of Council Meetings, St. Louis, June 20-23, 1946

Present: H. S. Rogers, N. W. Dougherty, H. M. Crothers, J. S. Thompson, F. L. Bishop, H. L. Dodge, L. J. Fletcher, C. E. Tucker, Joseph Weil, Thorndike Saville, R. H. Spahr, G. L. Sullivan, W. R. Woolrich, H. O. Croft, R. A. Deller, A. F. Greaves-Walker, W. C. White, D. C. Jackson, A. A. Potter, R. A. Seaton, W. E. Wickenden, C. C. Williams, H. P. Hammond, S. B. Earle, K. T. Compton, D. B. Prentice, H. T. Heald, R. E. Doherty (28).

The following actions were taken:

1. Reports of the Secretary and the Treasurer received and ordered printed in the JOURNAL OF ENGINEERING EDUCATION.

2. W. E. Wickenden elected to represent the Society on the American Council on Education.

3. W. R. Woolrich elected to represent the Society on the Engineers' Council for Professional Development.

4. $500 contributed to E.C.P.D. for the work of the Committee on Engineering Schools; $150 for brochure on condition that other societies contribute also.

5. The University of Washington Branch approved.

6. The Aeronautical Engineering Division approved; also the Agricultural Engineering Division approved.

7. 37 individual and 5 institutional members elected.

8. 41 members dropped for nonpayment of dues.

9. Approval given to the Upper New York Section to include the State of New York with the exception of the metropolitan region.

10. The incoming President is to appoint a committee to study the pattern of curricula designed to prepare graduates for basic scientific degrees.

11. Report on Professional Degrees adopted with minor corrections.

12. F. L. Bishop appointed Secretary of the Society.

13. The budget for 1946–47 approved.

14. The Society is to apply for membership in the National Science Teachers Association and the President is to appoint a consultant and an alternate.

15. Consensus of Council that Sunday meetings be avoided, if possible, without criticism of those meetings which have been held.

16. The Model Law approved and notice sent to American Society of Civil Engineers.

17. Advertising of positions should be made possible in the JOURNAL.

18. Resolution passed expressing the appreciation of the Society to the University of Pittsburgh for its generous contributions to the Society in space and other facilities.

Members Elected

ALLEN, VICTOR T., Professor and Director, Dept. of Geology, Institute of Geophysical Technology, St. Louis University, St. Louis, Mo.

BAKER, LEE R., Director of Graduate School, Chrysler Institute of Engineering, Detroit, Mich.

BATOR, GEORGE T., Assistant Professor of Mining Engineering, University of Alabama, University, Ala.

BLUM, VICTOR J., Assistant Dean, Institute of Geophysical Technology, St. Louis University, St. Louis, Mo.

CHAPIN, LLOYD W., Registrar, Georgia School of Technology, Atlanta, Ga.

COVELLE, LLOYD K., Vice Director of Engineering Extension, Oklahoma A. & M. College, Stillwater, Okla.

CUSACHS, LOUIS, Assistant Director, Engineering Experiment Station, Louisiana University, Baton Rouge, La.

FETHERSTONHAUGH, EDWARD P., Dean, Faculty of Engineering and Architecture, University of Manitoba, Winnipeg, Man.

FRANK, ALBERT J., Instructor in Geology, Institute of Geophysical Technology, St. Louis University, St. Louis, Mo.

FULMER, HERMAN K., Associate Professor of Mathematics, Georgia School of Tech., Atlanta, Ga.

GIBBS, R. C., Professor of Physics, Cornell University, Ithaca, N. Y.

GOETZENBERGER, RALPH L., Vice President, Minneapolis-Honeywell Regulator Co., Washington, D. C.

GRALAK, STANLEY D., Assistant Professor of Mechanical Engineering, Michigan State College, East Lansing, Mich.

GRASSI, RAYMOND C., Assistant Professor of Mechanical Engineering, University of California, Berkeley, Calif.

HARRIS, ELWOOD K., Chairman, Drawing and Design Dept., General Motors Inst., Flint, Mich.

HARRIS, MARK P., Instructor in Drawing and Mechanics, Georgia School of Tech., Atlanta, Ga.

HEDRICH, WALTER A., Assistant Professor of Electrical Engineering, Mich. State College, East Lansing, Mich.

JARVI, ALBERT O., Instructor in General Engineering, University of Washington, Seattle, Wash.

KAHN, BERNARD, Instructor in Physics, Newark College of Engineering, Newark, N. J.

KALLENBERGER, ROY O., Instructor in Electrical Engineering, Marquette University, Milwaukee, Wis.

KLEIN, FREDERICK, Instructor in Geophysical Engineering, St. Louis University, St. Louis, Mo.

KOERPER, E. C., Engineer in charge of special projects, A. O. Smith Corp., Milwaukee, Wis.

LOUGHMILLER, KENNETH M., Assistant Professor of Mechanical Engineering, University of Louisiana, Baton Rouge, La.

MACALPINE, DAVID M., Associate Professor of Engineering, Montana State College, Bozeman, Mont.

MARTIN, GEORGE H., Instructor in Mechanical Engineering Illinois Institute of Technology, Chicago, Ill.

OWEN, GWILYM E., Professor and Head, Dept. of Physics, Antioch College, Yellow Springs, Ohio.

PANLENER, RICHARD J., Director of Industrial Relations, Marquette University, Milwaukee, Wis.

POPE, ALAN Y., Associate Professor of Aeronautics, Georgia School of Technology, Atlanta, Ga.

POWERS, PHILIP N., Chief, Scientific Education Branch, Office of Research and Invention, Washington, D. C.

ROBERTS, DONALD S., Personnel Engineer, General Electric Company, Schenectady, N. Y.

RULEY, BRYCE T., Stress Analyst, S.K.F. Industries, Inc., 1414 The Kenilworth, Philadelphia, Pa.

SANFORD, CARL N., Professor and Head, Dept. of Aeronautical Engineering, Iowa State College, Ames, Iowa.

SCHRUBEN, L. R., Assistant Professor of Engineering Drawing, University of Michigan, Ann Arbor, Mich.

SMITH, JOSEPH M., Assistant Professor of Chemical Engineering, Purdue University, Lafayette, Ind.

SWANNER, JAMES C., Assistant Professor of Engineering Drawing and Design, Alabama Poly. Inst., Auburn, Ala.

WENN, FRED B., Professor of Industrial Management, Georgia School of Technology, Atlanta, Ga.

ZSUFFA, LESLIE F., Director, Public Relations, Georgia School of Technology, Atlanta, Ga.

Institutional Members

The Institute of Ceramic Engineers, Robert Twells, Secretary-Treasurer, Electric Auto-Lite Co., Fostoria, Ohio.

Institute of Geophysical Technology, St. Louis University, St. Louis, Mo. James B. Macelwane, Dean.

San Jose State College, San Jose, Calif. Ralph Smith, Professor.

University of Buffalo, Buffalo, N. Y. Paul E. Mohn, Dean.

Dayton Y. M. C. A. College, 117 West Monument Ave., Dayton, Ohio. C. Carleton Perry, Assistant Director.

Budget for 1946–47

RECEIPTS:			
Current dues, 3,400 individual	$5 = $17,000		
Institutional 69	$50 = $3,450		
70	35 = 2,450		
26	25 = 650	6,550	$23,550.00
Back dues			1,000.00
Advertising			4,500.00
Sale of publications			450.00
Interest on bonds			300.00
Total estimated receipts			$29,800.00
DISBURSEMENTS:			
Eng. Coll. Adm. Council		$ 2,000.00	
Eng. Coll. Res. Council		2,500.00	
JOURNAL and *Proceedings*		12,000.00	
Committees		700.00	
Secretary's honorarium		2,200.00	
Clerical assistance		4,500.00	
Officers' travel		500.00	
Office of Secretary travel		400.00	
E.C.P.D.: Contributions:			
Engineering Schools	$500.00		
Brochure	150.00	650.00	
Dues: American Council Education		100.00	
Nat. Sci. Teachers Assoc.		50.00	
Drawing Division		300.00	
Special activities		300.00	
Post., telephone and telegraph		1,400.00	
Sundry printing		900.00	
Emergency		1,000.00	29,500.00
Estimated surplus			$ 300.00

Respectfully submitted,
F. L. BISHOP,
Secretary

Minutes of the 54th Annual Meeting, S.P.E.E.

The 54th annual meeting of the Society for the Promotion of Engineering Education was held in the Jefferson Hotel, St. Louis, Mo., June 20–23, 1946, Washington University our host. Almost a thousand members and guests registered.

There were four regular sessions of the Society, Harry S. Rogers, President of the Society, presiding, and 26 conference groups held meetings. Five hundred attended the annual dinner on Saturday evening.

The Local Committee was in charge of Dean A. S. Langsdorf, General Chairman, with the following aides: Mrs. E. O. Sweetser, Women's Committee; N. H. Ceaglske, Hotels; D. A. Fischer, Dinners and Luncheons; R. R. Tucker, Finance; A. E. Fitch, Program and Rooms; A. M. Buchan, Printing; E. O. Sweetser, Registration; H. Kuenzel, Hospitality; R. S. Glasgow, Transportation; and R. W. Bockhorst, Drawing Summer School.

The first general session was held in the Graham Memorial Chapel, Washington University. Members and guests were transported by buses to and from the hotel and the campus. Chancellor Arthur H. Compton welcomed the Society and spoke on The Engineer as a Builder of Society. President Rogers gave the presidential address, Threshold of the New Era; S. S. Steinberg spoke on Engineering Education in Latin America; and Karl T. Compton, Chairman, presented the report of the Committee on the Outlook and Demand for and Supply of Engineering Graduates.

The second general session was held in the Gold Room of the Jefferson Hotel, and was devoted to Humanistic-Social Studies, the following papers being presented: Philosophy of Humanistic-Social Studies in Engineering Education, Edward S. Burdell; Planning the Professional Aspects of the Humanistic-Social Courses, B. Richard Teare; Summary of Information Concerning Humanistic-Social Courses in Engineering Colleges, Lisle A. Rose; Practical Economics for Engineers, Charles E. Young.

The third general session was devoted to action on the report of the Committee on Revision of the Constitution and By-Laws. It was the unanimous vote of the members present that the report be accepted as printed in the April JOURNAL OF ENGINEERING EDUCATION, and that the name of the Society be changed to the AMERICAN SOCIETY FOR ENGINEERING EDUCATION.

At the annual dinner on Saturday evening, Edwin C. Elliott, President Emeritus of Purdue University, spoke on Trivia from Oblivia. The Lamme Medal was conferred upon Robert E. Doherty, Carnegie Institute of Technology. The George Westinghouse Award was made to Joseph N. Goodier, Cornell University. This award was $1,000.00 and a certificate. The following officers were elected:

President (one year) Huber O. Croft, Professor of Mechanical Engineering, State University of Iowa.

Vice President (one year general

and regional activities) Earle B. Norris, Dean of Engineering, Virginia Polytechnic Institute.

Vice President (two years, instructional divisions) C. J. Freund, Dean of Engineering, University of Detroit.

Treasurer (one year) James S. Thompson, President, McGraw-Hill Book Company.

Previous to this election, F. M. Dawson, Dean of Engineering, State University of Iowa, had been elected Vice President in charge of the Engineering College Research Council; and J. R. Killian, Executive Vice President, Massachusetts Institute of Technology, Vice President in charge of the Engineering College Administrative Council.

At the fourth session the following papers and reports were presented: Selection and Guidance, K. W. Vaughn; Employment Histories of Engineering Graduates, Everett D. Howe; Report on Research Activities of the Southeastern Section; and reports on the Division of Administrative Officers of Engineering College, and Engineering College Research Association.

The following resolution was unanimously adopted by a rising vote:

WHEREAS, The 54th Annual Meeting of the Society for the Promotion of Engineering Education is now nearing the close of one of the most successful meetings in its history, and

WHEREAS, All of those in attendance at this meeting, members, their families and guests have thoroughly enjoyed the hospitality which we have experienced in this historic, friendly and beautiful city of St. Louis, located on the Father of Waters in the heart of the midwest; now therefore be it

RESOLVED, That the collective thanks and appreciation of all be extended to Chancellor Compton and Dean Langsdorf of Washington University, our host institution, which among other courtesies supplied bus transportation to their beautiful campus, the dinner of the Council; and to Professor E. O. Sweetser and his committee on local arrangements, to Margaret Spindler, Secretary to Dean Langsdorf, who rendered such able assistance at convention headquarters, to the St. Louis Convention Bureau of the Chamber of Commerce, who provided registration service, and last but not least, to the charming hostesses of the Women's Hospitality Committee under the Chairmanship of Mrs. E. O. Sweetser, who have entertained our lovely ladies and taken them off our hands temporarily while we transacted the serious affairs of engineering education.

Report of Treasurer, Jas. S. Thompson

I have audited, as of this date, the accounts of the Society for the year ending June 30, 1946, and enclose herewith in triplicate, the following statements:

1. Statement of Cash Account.
2. Statement of Income and Expense.
3. Balance Sheet.

In accordance with your request, these statements have been prepared in comparative form, and have been prepared from records and information furnished by your office. Cancelled checks have been examined and compared with supporting invoices. Classification of expenditures has been made in accordance with your book records. All receipts have been verified to bank deposits and balanced to your bank statements.

In view of the fact that your annual meeting is being held prior to the end of your fiscal year, it has been necessary to prepare these reports at this date. We have anticipated expenses for salaries to June 30, and have so recorded them in the reports. Conservative allowances have been made for accounts payable and receivable so that the income and expense statement will reflect a close approximation to your final surplus for the period.

Attention should be called to the fact that the Lamme Award Fund has been unable to reimburse the Society for $191.49 advanced during 1944. It is suggested that action be taken to write this receivable off against expenses of the Society, unless some other method for reimbursement can be arranged. The Savings Account has also been closed by the purchase of additional Government Savings Bonds.

It is my belief that the attached statements show a true financial condition of the Society at this date.

Sincerely yours,
H. E. Daer

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION
COMPARATIVE STATEMENT OF CASH ACCOUNT

June 12, 1946

	1944–45 (May 22, 1945)	1945–46 (June 12, 1946)
BALANCE ON HAND:		
Forbes National Bank—Checking Account	$14,161.74	$13,227.07
Forbes National Bank—Savings Account	636.07	639.25
Total Balance	$14,797.81	$13,866.32
RECEIPTS:		
Current Dues	$16,912.24	$17,346.41
Back Dues	1,891.50	1,560.00
Dues in Advance	235.00	517.50
Sales of Publications	832.36	1,002.17
Advertising	3,703.93	4,304.02
Sale of Emblems	47.25	12.25
Interest on Savings Account	3.18	3.20
Interest on Government Bonds	218.75	258.75
Refund—University of Tennessee Humanistic-Social Studies Division	—	164.40
Refund—to close Summer Session Account	—	104.77
Receipts from Dinners	—	371.00
Total Receipts	$23,844.21	$25,644.47

DISBURSEMENTS:		
Cost of Publications	$ 8,649.45	$10,474.28
Honorarium for Secretary	2,000.00	2,000.00
Clerical Assistance	4,225.00	4,172.25
Travel and Entertainment—Secretary's Office	231.90	407.62
Printing, Postage, Office Supplies, etc.	1,352.27	986.20
Purchase of Equipment	—	648.78
Dues—American Council of Education	100.00	100.00
Contribution to Engineers' Council for Professional Development	250.00	750.00
Officers' Traveling Expenses	66.34	477.83
Expenses—1944 Meeting	680.98	—
Expenses—1945 Meeting	59.17	153.85
Expenses—1946 Meeting	—	410.22
Expenses—Administrators Division	870.43	520.17
Expenses—Committee on Engineering Education after War	315.16	—
Expenses—Civil Engineering Division	186.88	156.27
Expenses—Conference on Social Humanities Problems	172.02	—
Expenses—Physics Division	9.44	—
Expenses—Committee on Graduate Studies	209.19	—
Expenses—Revision of Constitution	637.47	390.89
Expenses—Committees and Conferences	—	711.15
Council Meeting	—	335.35
Disbursement for Purchase of Series "G" Government Bonds	2,500.00	700.00
Refund of Gift from Rockefeller Foundation	1,800.00	—
Advance to University of Tennessee Humanistic-Social Studies Division	460.00	—
Total Disbursements	$24,775.70	$23,394.86
BALANCE ON HAND:		
Forbes National Bank—Checking Account	$13,227.07	$16,115.93
Forbes National Bank—Savings Account	639.25	—
Total Balance on Hand	$13,866.32	$16,115.93

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION
COMPARATIVE STATEMENT OF INCOME AND EXPENSE

For the Years Ending June 30, 1945 and 1946

Income:	1944–45 (May 22, 1945)	1945–46 (June 12, 1946)
Current Dues	$18,159.74	$18,581.41
Back Dues	891.50	560.00
Sale of Publications	832.36	1,002.17
Advertising	3,803.93	4,404.02
Sales of Emblems	47.25	12.25
Interest on Savings Account	3.18	3.20
Interest on Government Bonds	218.75	258.75
Refunds to Close Summer Session Account	—	104.77
Receipts from Dinners	—	371.00
Total Income	$23,956.71	$25,297.57

Expense:		
Cost of Publications	$ 9,549.45	$10,274.28
Expenses—1944 Meeting (1945)	1,072.56	213.02
Honorarium for Secretary	2,000.00	2,000.00
Clerical Assistance	4,225.00	4,172.25
Printing, Postage, Office Supplies, etc.	1,381.27	986.20
Travel and Entertainment—Secretary's Office	231.90	407.62
Dues—American Council on Education	100.00	100.00
Contribution to Engineers' Council for Professional Development	250.00	750.00
Officers' Traveling Expenses	66.34	477.83
Expenses—Administrators Division	870.43	520.17
Expenses—Committee on Engineering Education after War	315.16	—
Expenses—Civil Engineering Division	186.88	156.27
Expenses—Conference on Social Humanities Problems	172.02	295.60
Expenses—Physics Division	9.44	—
Expenses—Committee on Graduate Studies	209.19	—
Expenses—Revision of Constitution	637.47	390.89
Expenses—Committees and Conferences	—	711.15
Council Meeting	—	335.35
Total Expense	$21,277.11	$21,790.63
Surplus for the Year	2,679.60	3,506.94
Total	$23,956.71	$25,297.57

SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION
COMPARATIVE BALANCE SHEET

As of June 30, 1945 and 1946

ASSETS

	1945 (May 22, 1945)	1946 (June 12, 1946)
Cash:		
Current Fund	$13,227.07	$16,115.93
Petty Cash Fund	300.00	300.00
Life Membership Fund	931.91	1,045.92
Savings Account	639.25	—
Total Cash	$15,098.23	$17,461.85
Securities:		
United States Government Bonds—Series "G"	$10,000.00	$10,700.00
Benjamin G. Lamme Trust Fund:		
Securities and Mortgages	$ 5,056.00	$ 5,108.41
Uninvested Cash	88.25	35.84
Checking Account	263.71	178.54
Total Lamme Fund	$ 5,407.96	$ 5,322.79
Prepaid Expenses: 1945 Meeting (1946)	$ 59.17	$ 410.22
Inventory (Nominal)	1.00	1.00
Accounts Receivable:		
Advertising	1,100.00	1,200.00
Dues	1,000.00	1,000.00
Benj. G. Lamme Award	191.49	191.49
Advance to University of Tennessee for Humanities Social Studies Division	460.00	—
Furniture and Fixtures (Nominal)	100.00	748.78
Total Assets	$33,417.85	$37,036.13

LIABILITIES

	1945 (May 22, 1945)	1946 (June 12, 1946)
Life Membership Fund	$ 931.91	$ 1,045.92
Benj. G. Lamme Trust Fund	5,407.96	5,322.79
Prepaid Membership Dues	235.00	517.50
Accounts Payable	2,200.00	2,000.00
Total Liabilities	$ 8,774.87	$ 8,886.21

SURPLUS ACCOUNT

Balance	$21,963.38	$24,642.98
Surplus for Year	2,679.60	3,506.94
Total Surplus	$24,642.98	$28,149.92
Total Liabilities and Surplus	$33,417.85	$37,036.13

The Outlook in the Demands for and Supply of Engineering Graduates*

Manpower—that is, the availability of personnel with the proper skills, at a given place and time and with the willingness to work—has been and continues to be a major problem in most areas of activity. The primary objective of this report is to study the needs for and supply of a small but very important segment of the working population, the engineering group.

Several studies covering engineering manpower have been made in the last few years, notably Dean Potter's industrial survey of April 1945, the report made jointly by the American Council on Education and the Office of Scientific Personnel of the National Research Council published in May 1945, the Bush report "Science, the Endless Frontier" July 1945, and more recently the study made by Professor R. C. Price of New York University entitled "Engineers: Wanted," published in this issue of the JOURNAL OF ENGINEERING EDUCATION.

Scope and Limitations

For the purposes of this report, studies covering only *engineering* graduates have been included, despite the acknowledged increasing interdependence of engineers and scientists. A similar survey covering the sciences is reported to be under consideration; such a survey will supplement this report to give a complete picture of scientific and engineering manpower. The analyses of the statistical data have been confined to six major fields—aeronautical, chemical, civil, electrical, mechanical, and mining and metallurgical—without any implication that the several other fields are less important. Only the needs for engineering graduates within the United States have been taken into account, although the committee recognizes the great demands which will be made on the American engineering fraternity to help in the reconstruction of the devastated areas of the world.

Quantitative evaluation of supply versus needs is a hazardous undertaking at best. The wartime dislocation of normal supply of engineering graduates and likewise of normal demands, the speed with which American industry can reorient itself for peacetime operation, the success with which industry can cope with the vagaries of general business conditions, the ultimate action by the Congress on universal military training—or the extension of Selective Service,—the establishment of a National Science Foundation, the Congressional action on appropriations for the several military and civilian agencies of the government—all of these factors and many others militate against a precise quantitative answer. Of perhaps greater significance to the long-term picture are the expanded horizons—some new, others given great impetus as a result of wartime developments—the possible initiation of an atomic energy program supported in part by government funds,

* Presented at the 54th annual meeting, S.P.E.E., St. Louis, June 20–23, 1946.

gas turbine development, instrumentation and servomechanisms, to mention only a few. One can only guess about the magnitude of the needs for trained engineering personnel in these fields.

Demands

In attempting to forecast trends over the next few years, one might begin by assuming that the trends of the past two decades will, in general, continue. However valid this appears to be, it would ignore the recognized fact that the first World War gave a great stimulus to technological development in the United States. The same thing will undoubtedly take place after this war in a number of fields that were prominent in the conduct of the war, such as electronics. Furthermore the tremendous amount of research in applied science during the war and the brilliant results produced forecast a much greater emphasis on research in industry. This is borne out not only by the returns from industry in this survey and in the "opinion poll" which accompanied it, but also by a survey conducted approximately a year and a half ago by the Industrial Research Institute and by a survey just concluded by the National Research Council, which is to be published shortly.

Prospective Government Employment

The trend in government employment of engineers is sharply upward, but detailed estimates at the present time are not definite enough to warrant quotation, because Congress has not yet finally approved any peacetime budget.

Even so, the likelihood is for a sharp increase in employment of engineers. The navy, for example, plans at present to hire in the next two years almost as many professional technical personnel as now employed, or about 11,000 more, for a total in 1948 of 22,000. These will be in large part engineers. The army will similarly employ many more than before the war. The army reports a current total of 13,000 civilian engineers and 6,000 engineers in uniform, and plans to maintain this strength. In addition, the army has budgeted for 3,800 more engineering graduates in the near future. The employment at Wright Field is approximately ten times what it was before the war. Both the navy and the army military personnel will include many more engineers than heretofore. Since the employment of engineers by the services both for military and civilian posts before the war was not large, this is in effect a new field of service for the engineering personnel of the nation.

Industrial Needs

The industrial picture is rendered clearer by the information, both qualitative and quantitative, supplied by the 125 companies which completed the S.P.E.E. questionnaire, and by the results of the independent "opinion poll" summarized below.

The questionnaires covered the total number of engineering graduates now employed in research and development and the total in production, sales, and management, as well as the immediate and long-term needs for additional engineering personnel. The data were broken down into the six major fields given above, and according to first and advanced degrees. For comparative purposes similar data were obtained covering 1937–39 (average).

A summary of the industrial survey is given in Table I, and shows an increase in employment of engineers from 1938 to the present time of 56 per cent

TABLE I

COMPARATIVE EMPLOYMENT OF AND NEEDS FOR ENGINEERING GRADUATES
(Based on survey among 125 companies)

	Research and Development			Production, Sales and Management			Overall change since 1938
	1937–39	1946	Change since 1938	1937–39	1946	Change since 1938	
No. of engineering graduates employed	7,074	12,895	+ 82%	9,303	12,661	36%	+ 56%
Additional engineers needed:							
1937–39 Bachelors	866			899			
1937–39 Advanced degrees	135			76			
1946 Bachelors		1,096	+ 27%		1,170	+35%	+ 29%
1946 Advanced degrees		257	+ 91%		43	−43%	+ 42%
Future annual Bachelors		2,084	+141%		1,662	+85%	+112%
Future annual Advanced degrees		492	+264%		114	+50%	+187%
Percentage of engineers needed in terms of total engineers employed:							
1937–39	14%			10%			
1946		10%			10%		
Future annual		20%			14%		

It is interesting to note that the increase in the number of engineers engaged in research and development in the last eight years was 82 per cent, while those engaged in production, management, and sales the increase was 36 per cent.

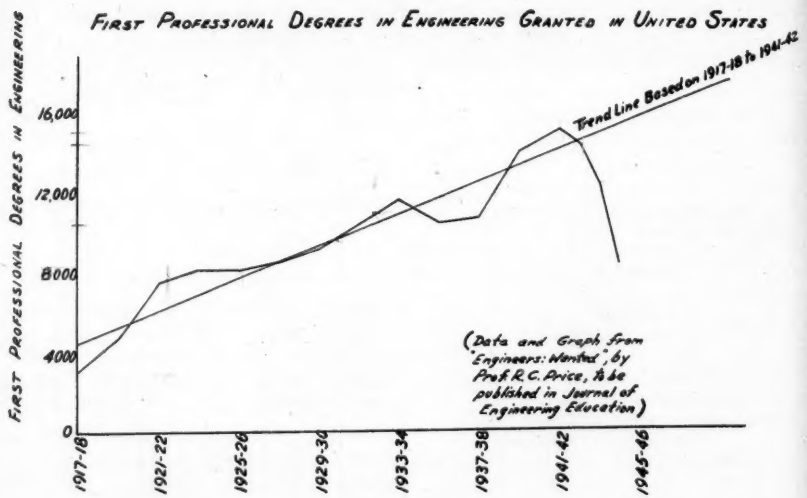
Relating the current and future annual needs for these companies to the number of inexperienced men hired eight years ago should give an index of the magnitude of the overall demands for engineering graduates, if the 125 companies are a representative sample of American industry, and if the estimates of the 125 personnel directors are reasonably accurate. For example, the average number of first degree graduates in the period 1937–39 was 9,810; accordingly the overall annual need for first degree graduates could be estimated at 20,800, using the factor of 112 per cent increase shown in Table I. This projected annual demand tallies closely with the estimated normal production in 1952 based on the trend in the first degrees granted, shown in Table II on page 28.

The number of new engineers added in 1938 was 12 per cent of the number of engineers employed at that time, the increment among research engineers being 14 per cent, while for production engineers it was 10 per cent. Current employment needs are stated as the additions budgeted for the next six months and are about 10 per cent of current employment, the ratios of need to present employment being the same in the two subdivisions of the study. Future annual needs are indicated as 17 per cent of current employment for each year beginning in 1947, the increase in research being 20 per cent, while for production it is 14 per cent.

A detailed summary of the data provided by the 125 companies is given in Appendices A, B, and C.

The future demand for aeronautical engineers is very much larger than the

TABLE II



average, in both research and production. In civil engineering and electrical engineering, it is above the average in research, but less than the average for chemical, mechanical, and mining and metallurgical engineering in research. No other significant differences from the averages are evident from the sample.

Not only are the companies increasing the ratio of research engineers to total engineers, but in the research field, they indicate a need for a higher percentage of engineers holding advanced degrees, while the opposite is true in production, sales, and management. The following table shows the trends in this respect:

PERCENTAGE OF ADDITIONAL ENGINEERS NEEDED HOLDING ADVANCED DEGREES

	Research and Development	Production, Sales and Management
1938.....	14%	8%
1946.....	19%	4%
Future.....	19%	7%

This sharp increase in emphasis on research and development is a very significant factor in any determination of future needs for engineers in that it tallies with the demand for more engineers with advanced degrees, and may well point to the increasing need for the extension of more basic science in undergraduate engineering curricula. Both of these points have been emphasized in recent years by engineering educators who have watched the trend away from "handbook" engineering and toward the application of more fundamental science to modern engineering problems. The needs of industry forecast a continuing change in engineering curricula.

Starting Salaries

One measure of the present scarcity of trained engineers is the trend in starting salaries for inexperienced men. The distribution of starting monthly salaries is shown in Appendix D; the

following table gives the comparative prewar and current averages:

	1939	Current	Increase over 1939
B.S.	$145	$210	45%
M.S.	180	240	33%
D.Sc.	215	300	40%

Training Programs

The industrial survey included a study of the practices followed with respect to training programs for young engineers. Half of the companies have such programs, varying in length from one to two years. Ten of the companies have instituted training programs within the last year, and another fifteen plan to start them in the near future. The fact that twenty-six per cent of the companies make provision in this way for upgrading subprofessional personnel into professional positions indicates the way in which a small part of the technical manpower shortage has been met.

Comments of Industrialists

Statistical data covering the probable demands for engineering graduates give only a partial picture. The opinions and comments of the personnel directors add significantly to an understanding of the many facets of the overall problem. Selected quotations are given in Appendix E; the men quoted are not identified, in keeping with assurances given when the survey was made.

Opinion Poll

To broaden the base further in appraising the outlook and to get the answers to three other questions which are of general interest to both industry and engineering colleges, representatives of the American Telephone and Telegraph Company sampled opinion among another 100 companies. The results are tabulated below; significant quotations from the answers to the questions are given in Appendix F.

1. "How do employment needs in the engineering department now (and prospective needs for the next year or so) compare with normal?"

Replies

Needs above normal	64%
Needs normal	25%
Needs below normal	10%
No comment	1%

2. "What is your opinion of the engineering graduates?"

Replies

Excellent or very good	12%
Satisfactory	38%
Deficient in certain particulars	35%
No opinion	15%

Deficiencies reported can be grouped as follows:

Human relations	9
Use of English	9
Accelerated course graduates below par	7
Lack practical perspective	5
Lack training in business	2
Lack ability in design	2
Training too theoretical, needs broadening	2

3. What do you think of the cooperatively trained engineer?"

Replies

Very satisfactory	23%
Opinion favorable	23%
No significant difference	8%
Below standard	4%
No opinion	19%
No experience but approved idea	20%
Opposed to interruptions in study	2%
Theory good but application impractical	1%

4. "In your observation has the war experience of manufacturing companies increased their dependence upon and use of engineers?"

Replies	
Yes (Many very emphatic)	73%
No	21%
No opinion	6%

Estimated Demand Based on Bureau of Labor Statistics Data

The returns from industry represent a sampling of the employment of engineers. However, the simple process of extrapolation to project the needs of the country as a whole would not necessarily give a reliable quantitative measure. Therefore, to get further independent evidence, the committee evaluated data provided by the Bureau of Labor Statistics of the U. S. Labor Department, which is currently carrying on a similar study to serve as a basis for future guidance activities.

The 1940 Census shows that the total number of employed persons in the United States in that year was about 45 million, of whom about 246 thousand were engineers. (In addition, there were 16 thousand engineers unemployed in 1940.) Under conditions of "full employment" B.L.S. estimates total employment at 57½ million persons, an increase of 28 per cent over the 1940 figure. If engineers were to increase in the same proportion, "full employment" would require about 315 thousand engineers.

Since it is obvious that increases among engineers would not be uniform in all activities, B.L.S. has computed the ratio of engineers to total employment in each of the principal industrial activities, based on census figures and their own records. They find that, while there are variations in individual activities, the general average of these ratios increased from 1930 to 1940, but decreased from 1940 to 1944. They have also estimated, for each of these activities, the total employment under conditions of full employment, and conclude that the activities which employ the largest numbers of engineers will show the largest increases in total employment.

On the assumption that the B.L.S. estimates of employment in each industry are sound, and on the further assumption that the ratios of engineers to total employment will be the same under full employment as in 1940, the number of engineers required under full employment will be at least 337 thousand. This is somewhat higher than the above estimate of 315 thousand, but considerably lower than the projected demands based on still another type of index used by the B.L.S.

The committee agrees as to the uncertainties inherent in the assumption that the ratios of engineers to total employment will be the same as in 1940, but we believe that in the absence of any better estimate, the figure 337 thousand will serve as a reasonable guide with respect to the future needs of engineers.

We further assume that this condition is to be achieved by 1950. Since there were 261 thousand engineers in 1940, 76 thousand will have to be added during the decade 1940 to 1950, in addition to the number needed to offset the attrition caused by death, retirement, and leaving the profession. If we subtract from this the number of engineering degrees granted since 1940, the remainder will be the number needed between now and 1950.

Attrition due to death has been computed by B.L.S. from life expectancy tables and age distribution tables for the engineering profession, as 1¼ per cent per year. The attrition due to retirement and leaving the profession is much harder to estimate, since no real data are at hand. However, the National Roster of Scientific and Special-

ized Personnel has estimated, from its experience in handling registration of engineers, that it amounts to approximately 1¾ per cent per year. This, added to the attrition due to death, gives a total of about 3 per cent per year. To simplify computation, we have called this a total of 30 per cent for the decade.

According to the annual reports of S.P.E.E., about 57 thousand first degrees in engineering were granted from 1940 to 1945. An estimated 7 thousand degrees will be conferred by the engineering colleges this year, making a total of about 64 thousand degrees through 1946.

In summary, the need for engineers will be:

Total number needed in 1950	337	thousand
Number available in 1940 (Including 16 unemployed)	261	"
	76	"
Attrition (30 per cent of 261)	78	"
Additions needed 1940 to 1950	154	"
Degrees granted 1941 to 1946	64	"
Needed 1946 to 1950	90	"

This represents a need for approximately 23 thousand engineers per year for the next four years, which is 9.4 per cent of the 246 thousand engineers employed in 1940. Replies from the 125 companies show that they have realized a net increase of 56 per cent since 1938 in the number of engineers employed, and that they estimate a need for the next few years of annual increases amounting to about 17 per cent of present employment.

The difference between the estimate based on B.L.S. data and those of the personnel officers is at least partially accounted for by the fact that in an individual company there is a fourth kind of attrition which does not enter into the national picture, that of men transferring from one company to another. This fourth type of attrition is almost impossible to measure, but should be considered in comparing the B.L.S. and industrial data. The first three types of attrition which are included in our estimate account for slightly more than one-half of the total estimated needs.

Factors Affecting Reliability of Estimate

The limits of reliability in any such estimate as this must be rather wide. There is doubt as to the validity of the assumptions on which the "total number needed in 1950" is based, as to whether or not full employment will be realized in 1950, and as to the proper allowance to be made for attrition.

Some observers feel that the ratios of engineers to total employment will be smaller under full employment than in 1940. They point to the fact that in 1940 there were some 8 million persons unemployed in this country, but that engineers had not been "laid off" in as large a proportion as had skilled and semi-skilled labor. Many industries had retained their engineering staffs largely intact, a fact which enabled them to make the tremendous advances in production from 1940 to 1944 with relatively small additions to these staffs. During these years the ratios of engineers in most industries were reduced, which indicates that increases in total employment do not require proportionate increases in engineers.

On the other hand, these ratios rose between 1930 and 1940. The decrease in the ratios from 1940 to 1944 may be accounted for by the fact that much of the tremendous production during

the war consisted of the manufacture of very large numbers of identical units, requiring a minimum of design and development, and produced with much less than the usual attention to cost. The normal inter-company and inter-industry competition was largely absent, and conditions in general were decidedly abnormal. Selective Service withdrew thousands of engineers from industry, who could not be replaced because the young men coming out of college were also being inducted into the armed forces, either before or immediately after graduation.

However, it is our opinion that the decreases in the ratios from 1940 to 1944 should be disregarded in attempting to forecast the future. The factors tending to decrease the ratios will be more than offset by other factors such as the increased emphasis on research in industry, already mentioned, and the increased dependence of industry upon engineering, indicated by the "opinion poll."

The following reasons, not reflected in the S.P.E.E. survey, gives credence to the belief that the estimated need for 23,000 additional engineers per year until 1950 may be too low:

(1) The survey indicates a vertical increase in the needs for engineers in each company, but does not reflect a horizontal spread of demands for engineers in companies not heretofore using professional technical personnel.

(2) The survey does not adequately reflect the new demands of the armed services for civilian and military personnel with engineering training. That this is substantial was indicated above.

(3) The possible effect of new demands created by the proposed legislation in Congress on Atomic Energy and on a National Science Foundation is not reflected in the survey. These new demands for trained personnel will undoubtedly become realities prior to 1950.

(4) The demands of the colleges for increased faculty personnel, covered later in the report, are not included in the above totals.

(5) The demand for engineers for foreign service, especially in war-torn countries, are not included in the survey.

In view of the foregoing, the estimated need of 90 thousand engineers between now and 1950, breath-taking as it may appear, is likely to be conservative.

What proportion of the engineers employed by 1950 will be college graduates we do not know. Many companies made provision during the war for filling some of their engineering positions by upgrading sub-professional personnel, or what one industrialist referred to as "almost graduates."

The estimate of 23 thousand new engineers per year until 1950 is a *short*-term requirement. After supply and demand have been stabilized, the annual demand is estimated at 18,000, based on prewar trends. However, the expanding opportunities for engineers through new technical developments in industry and government lead to the conclusion that engineering school enrollment in any case must be maintained permanently on a higher level than at any time before the war.

Technical Institutes

Wartime conditions forced industry to turn increasingly to the use of semi-professional workers. Engineering

jobs were "broken down" and the simpler jobs resulting were assigned to persons with technical institute or E.S.M.W.T. training, under the supervision of fully trained engineers. Because this trend is likely to continue, particularly until the demands for and supply of engineering graduates are equalized, and because of the recognized long-term relationship between the needs for graduates of technical institutes and professional engineering schools, a subcommittee has prepared a report on technical institutes, which is given in Appendix G. On the basis of previous studies, the ratio of technical institute graduates to professional engineers runs between 3 and 5 to 1. Conservatively, therefore, the short-term annual need for the technical institute graduates will approximate 75,000. The ability of technical institutes to meet this demand is problematical; one mitigating factor is the large number of young men who were given training in the armed services and who will be available to partially meet the industrial demand.

Supply

What are the prospects that the engineering schools can produce enough graduates to meet these demands? The question is twofold, involving both the total production and the distribution of graduates among the several professional fields.

So far as supply is concerned, your committee has assumed that there will be an adequate number of qualified young men to fill to capacity even the expanded facilities of all of the engineering schools in this country, although some reports in the past have indicated that the number of trainable men in engineering is not greatly in excess of the normal capacity of the engineering schools. The backlog of men whose engineering training was interrupted and those who would have matriculated in engineering had it not been for the war, and the G.I. Bill, together make the assumption a safe one, at least for the short-term future. The new conditions imposed on veterans returning to school, such as two or more years' absence from academic life and the fact that many of them are married, may increase attrition. However 74 out of 83 deans of engineering estimate a lower academic mortality as compared to that among prewar civilian students, which indicates that added maturity and a higher degree of selection possible under present conditions will offset the adverse factors.

In retrospect one can identify tendencies and patterns of past enrollment in engineering schools which, interpreted within certain limits, can be of assistance in several respects. Administrative officers of engineering colleges can secure information helpful in determining needs for plant remodelling and enlargement, for faculty, and for modification in curricula. Interested public officials can secure information of help in placing veterans in colleges. Industry can gage the possible response to its needs for men. Since these factors are concerned with different facets of the problem of training engineers, the interests of all can be served by the collection and interpretation of data covering engineering school enrollments and degrees granted.

Comparative Engineering School Enrollment

Total full-time enrollment in engineering colleges rose from around 50 thousand in 1919–20 to a peak of 110 thousand in 1942–43. Following the depression-induced drop in the early

1930's, enrollment increased sharply beginning with 1935–36. Pearl Harbor set off the forces to stimulate further engineering enrollment, culminating in an all time maximum enrollment in 1942–43.

Table II shows the trend of first degrees granted in the United States since World War I.

When evening students are considered, no appreciable change in the trend appears. In 1935–36, the first year for which data are available, evening enrollment was 5,800. This increased to peak two years earlier than for full-time students, attaining 12,900 in 1940–41, then falling to 5,300 in 1943–44. In getting total registration, the numbers of evening students have been translated into equivalent full-time students by applying a factor of 0.45, which has been found to be accurate within 5 per cent in previous studies.

Following the initial surge, however, war-time civilian registration in engineering schools fell to the lowest level since World War I. The 31,400 full-time students of 1944–45 virtually equalled the 31,100 students of 1917–18.

Substantial numbers of men trained under A.S.T.P. and N.C.T.P compensated only in part. Even including students being trained under military programs, enrollment dropped to below 50 thousand (1944–45) or approximately to the 1919–20 level.

Nor does the drop in enrollment give the full significance of the war impact, especially with respect to the time within which present unfilled needs for engineers can be met. A study of the distribution of civilian undergraduates by classes reveals a drastic change from normal. Taking 1939–40 as a representative prewar year, the juniors and seniors constituted almost twice as large a share of the enrollment as in 1945–46. Comparative figures indicate the unprecedented size of the freshman class:

	1939–40 Per cent	April 15, 1946 Per cent
Freshman	34.2	52.1
Sophomore	25.9	23.9
Junior	21.0	14.5
Senior	18.0	7.9
Fifth year	0.9	1.6
	100.0	100.0

The total number of juniors and seniors is now less than in 1921–22. Similar figures for military enrollment are not available.

In interpreting enrollment figures, allowance must be made for the accelerated schedule in most engineering schools during the war, and, since the war, for the influx of veterans and others as advanced standing students. Without making such allowance, figures appear inconsistent. For example, in the fall of 1944–45 there were 2,373 seniors and 143 fifth-year men taking the five-year curriculum, or a total of 2,516. Yet during that same academic year 4,190 civilian graduates receiving first professional degrees were reported to the S.P.E.E.

A study of the distribution of civilian undergraduates by curricula demonstrates the rise of mechanical engineering students to a peak of nearly 30,800 in 1942–43, not far from double the 18,200 enrolled in chemical engineering or the 16,000 in electrical engineering. In the same year civil engineering with 11,900 enrollees exceeded aeronautical engineering with 5,300. Metallurgical and mining engineering trailed with 2,558 and 1,941 respectively. The comparative percentage distribution among the six curricula is shown in Table III.

TABLE III

DISTRIBUTION OF UNDERGRADUATE ENGINEERING STUDENTS AMONG CURRICULA

	1910–11	1920–21	1925–26	1930–31	1935–36	1940–41	Apr. 1946
	%	%	%	%	%	%	%
Aeronautical	—	—	0.2	2.7	2.8	3.7	4.9
Chemical	2.9	11.1	8.5	8.8	15.7	16.0	9.6
Civil	26.0	17.1	22.4	15.8	13.8	11.1	10.9
Electrical	18.0	18.2	32.7	21.3	18.3	15.4	20.5
Mechanical	21.0	22.7	19.0	15.8	20.6	28.4	21.2
Mining and metal.	8.7	6.2	3.1	2.4	4.0	4.5	2.1
Other	23.4	24.7	14.1	33.2	24.8	20.9	30.8
Total enrollment	30,337	51,908	54,337	73,386	60,395	100,657	85,000

The prewar industrial race with its emphasis on production and need for mechanical engineers has been succeeded by a relatively reduced student demand for that curriculum. Sharpest numerical increases in the 1945–46 registration as compared with 1944–45 appear, however, in mechanical engineering, then electrical engineering, then civil engineering, and finally chemical and aeronautical engineering. Greater proportional increase was shown in civil engineering with a rate of 95 per cent, followed by mechanical and electrical with around 88 per cent. It is still too early to predict within close limits the distribution of students during the immediate future.

The experience of admissions officers and counselors in engineering schools since V–J Day indicates clearly that returning veterans have been greatly influenced by their service experience in their choice of professional course. The glamour of radar and aeronautical engineering, for example, bids fair to upset the normal relationship between supply and demand for men in the several professional fields, unless the engineering schools take prompt steps to counteract the present trend. Your committee regards this as vital to the future well-being of both engineering graduates and the engineering schools and recommends the appointment of a committee to report on ways and means of meeting this problem. The limitations of physical facilities and staff will to some extent stem the rising tide, but the problem runs much deeper than arbitrarily telling a young man that space is not available in the course of his choice; fundamentally, it is a job of educating the young man to appreciate the opportunities that prevail in some of the fields which at the moment appear less glamorous.

Graduate Enrollment

Data on graduate enrollment are less revealing. Total graduates enrolled in engineering rose from 368 in 1921–22 to a maximum of nearly 5,550 in 1939–40. From this high, the numbers shrank to a low of 2,657 in 1943–44, and have now recovered to reach an estimated 5,400. The recovery is in part only apparent; full-time students working for a master's degree number 1,205 in 1945–46 as compared with 2,213 in 1938–39, while evening graduate students now number 2,069 as compared with 1,349 in 1938–39. Since the part-time and evening students

have not been placed on an equivalent basis, part of the recovery is illusory. This condition is even more marked with respect to candidates for the doctor's degree in engineering, where current registration of 374 is much less than the peak figures of 848 for 1939–40.

The various fields of graduate engineering training retain substantially the same positions as before the war with respect to enrollment. In order of enrollment for 1935–36, the major curricula follow: electrical engineering, chemical engineering, civil engineering, mechanical engineering, metallurgical engineering, and mining engineering. In 1945–46, the picture differs only in that mechanical engineering has taken third place, pushing civil back to fourth, while aeronautical engineering has taken sixth place, relegating mining engineering to seventh.

Estimated Rate of Production

With the foregoing information as background, the final and crucial question is: How soon can the engineering schools produce enough graduates to satisfy the needs?

Several factors militate against a precise answer to this question, such as, what is the maximum capacity of engineering schools to assimilate successfully the mass of returning veterans; will the schools be able to get sufficient additional staff to take care of the inflated enrollment; at what rate will those now in the armed services be discharged; will attrition among veterans be greater or less than the prewar rate; will the engineering colleges remain on the accelerated or continuous basis; will the apparent trend toward increased postgraduate enrollment materialize; and will selective service continue or will universal military training be adopted.

A recent survey among engineering schools sheds light on some of these questions; answers to the others are conjectural. The survey shows that the maximum capacity of engineering schools in the United States will be 155 thousand, or 37 per cent above the previous maximum of 113,500 in 1942–43. Corresponding figures on graduate enrollment are a peak of 7,000, or 26 per cent above the 5,547 in 1939–40. Forty per cent of the schools expect to reach peak enrollment by September, 1946, and another 39 per cent by the fall of 1947. Approximately one-third of the schools reported that about 36 thousand of their students were given military leave, of whom 16,500, or 45 per cent, had returned by last April. It is probable that a total of 100 thousand have thus far been given military leave from all schools, which means that roughly 50 thousand are still in service and are planning to return to school as soon as released from active duty. Slightly more than half of the schools plan to drop the accelerated program, although 62 per cent of the schools will operate continuously, leaving to the veteran the decision as to whether he will continue on a year-round basis.

Half of the schools reported a need for over 1,200 additional staff, which represents an increase of 30 per cent over their present staff. This may well foretell a total need for 2 thousand more teachers and assistants by next fall.

Certain rather arbitrary estimates and assumptions, listed in the following paragraphs, have been made in arriving at a quantitative solution to the problem of rate of supply. Admittedly, time may well prove one or more of

the assumptions incorrect; in evaluating the over-all problem, however, the committee concluded that the errors would compensate for each other.

A review of the average over-all attrition for the four years prior to 1941 shows that the total number of first degrees granted represents 53.8 per cent of the total number of registered freshmen four years earlier. If this percentage is applied to the number of freshmen in any given year, therefore, one can estimate the number of men who will receive degrees four years hence. Corresponding percentages of the sophomores and juniors are 64.7 per cent and 71.8 per cent, respectively.

Of the 50 thousand students on leave who have not yet returned to school, we estimate that half will return by next fall and the remaining half by September, 1947. In the absence of factual data on which to base an opinion, we have assumed that half of the veterans, as well as all students currently registered, will elect to attend school continuously and the remaining half to attend only during the regular academic year.

Further we assume that all future freshmen will attend only during the regular academic year and that the total freshman enrollment of the engineering schools will be held in the future in the same proportion in relation to total undergraduate enrollment as obtained in October, 1941, or 36.5 per cent. We have estimated that in the fall of 1946 and 1947, a total of 44 thousand *new* freshmen (including veterans) will be admitted each year. The total freshman class in each of these years is estimated to be 56,500 on the basis of a total enrollment in engineering schools of 155 thousand, the reported capacity. The difference between 56,500 and 44,000 represents the number of returning veterans previously enrolled who will be classified as freshmen each year. Since the future status of selective service and universal military training is problematical, we have assumed, for purposes of estimating the rate of production of engineering graduates, that none of the students currently enrolled or those who enter in the future will be drafted.

On the basis of anticipated maximum enrollment in the graduate schools of 7 thousand, we have estimated that 2,500 men with first degrees will undertake graduate study annually for the next several years. Estimating that 1 thousand men will receive advanced degrees in 1946, 1,500 in 1947, and 2,500 by 1948 and later, the net deficit in 1946 will be 1,500 and for 1947 it will be 1 thousand. Beginning in 1948, input and output in the graduate schools should balance and therefore have no net effect on the deficit or surplus of engineering graduates.

The deficit in engineering graduates through 1945 has been very conservatively estimated at 8 thousand. The 1946 production may reach 7 thousand, and since the annual needs for each of the next four years have been estimated as 23 thousand, the net deficit of 1946 will be over 25 thousand. The computation of the cumulative deficit in engineering graduates for the next several years is given in detail in Table IV.

Conclusions

On the basis of these estimates, the deficit of engineering graduates will have been wiped out by 1952. This means that the need for continuing engineering education at an overload level will lessen beginning with the entering freshman class in 1949. On the other hand, future developments on

TABLE IV

PROJECTED PRODUCTION AND DEFICIT OF ENGINEERING GRADUATES

Production	1946	1947	1948	1949	1950	1951	1952
Of those currently registered:							
53.8% of the 40,700 freshmen			10,950	10,950			
64.7% of the 18,700 sophomores		6,050	6,050				
71.8% of the 11,400 juniors		8,180					
Of those returning from leave of absence:							
(*a*) In 9/46: 53.8% of 12,500 freshmen				3,365	3,365		
64.7% of 12,500 sophomores			4,050	4,050			
(*b*) In 9/47: 53.8% of 12,500 freshmen					3,365	3,365	
64.7% of 12,500 sophomores				4,050	4,050		
Of the new freshmen entering:							
(*a*) In 9/46: 53.8% of 44,000					23,700		
(*b*) In 9/47: 53.8% of 44,000						23,700	
(*c*) In 9/48: 53.8% of 56,500							30,400
Total first degrees granted	7,000	14,230	21,050	22,415	34,480	27,065	30,400
Less number entering graduate school (net)	1,500	1,000	—	—	—	—	—
Net number available for employment	5,500	13,230	21,050	22,415	34,480	27,065	30,400
Deficit to date	8,000	25,500	35,270	37,220	37,805	21,325	12,260
Annual demand	23,000	23,000	23,000	23,000	18,000	18,000	18,000
Total demand	31,000	48,500	58,270	60,220	55,805	39,325	30,260
Cumulative deficit to date	25,500	35,270	37,220	37,805	21,325	12,260	140*

* Surplus.

the political, social, and economic fronts will have a marked effect on both the potential supply of and demand for technical personnel, and these may completely invalidate the conclusions reached in this report. Not the least of the possible factors to be considered is the continually growing clamor of labor for higher wages or a shorter work week or both. This development serves as a reminder that engineering progress in the past has been responsible in large measure for the improved standard of living. Full recognition by labor, management, and government alike of the immediate need to stimulate activity in both science and engineering will help to maintain and further improve the standard of living.

APPENDIX A

EMPLOYMENT OF AND NEEDS FOR ENGINEERS, RESEARCH AND DEVELOPMENT
(Survey of 125 companies in April 1946)

	No. of additional inexperienced engineering graduates employed each year 1937–39 (average) in Research and Development		Total no. engineering graduates engaged in Research and Development 1937–39 (average)	No. of additional inexperienced engineering graduates budgeted for next six months in Research and Development		Total no. engineering graduates now engaged in Research and Development in company	No. of additional inexperienced men needed each year for Research and Development beginning in 1947	
	B.S.	Adv. degrees		B.S.	Adv. degrees		B.S.	Adv. degrees
Aeronautical	66	12	266	258	55	1,198	287	95
Chemical	117	50	991	145	74	2,055	245	117
Civil	62	6	333	52	10	655	215	32
Electrical	234	17	2,864	164	41	4,047	600	75
Mechanical	346	37	2,369	421	58	4,373	638	111
Mining and metallurgical	23	10	144	42	5	221	46	29
Other	18	3	107	14	14	350	53	33
Total	866	135	7,074	1,096	257	12,895	2,084	492

APPENDIX B

EMPLOYMENT OF AND NEEDS FOR ENGINEERS, PRODUCTION, MANAGEMENT AND SALES
(Survey of 125 companies in April 1946)

	No. of additional inexperienced engineering graduates employed each year 1937–39 (average) in Production, Management and Sales		Total no. engineering graduates engaged in Production, Management and Sales 1937–39 (average)	No. of additional inexperienced engineering graduates budgeted for next six months in Production, Management and Sales		Total no. engineering graduates now engaged in Production, Management and Sales in company	No. of additional inexperienced men needed each year for Production, Management and Sales beginning in 1947	
	B.S.	Adv. degrees		B.S.	Adv. degrees		B.S.	Adv. degrees
Aeronautical	7	0	30	25	5	168	31	10
Chemical	121	16	1,099	89	5	1,863	200	46
Civil	84	3	1,415	59	0	1,087	147	3
Electrical	239	25	2,921	379	7	3,920	505	14
Mechanical	378	20	3,252	555	12	4,675	676	23
Mning and metallurgical	34	5	206	23	2	330	39	8
Other	36	7	380	40	12	618	64	10
Total	899	76	9,303	1,170	4	12,661	1,662	114

APPENDIX C

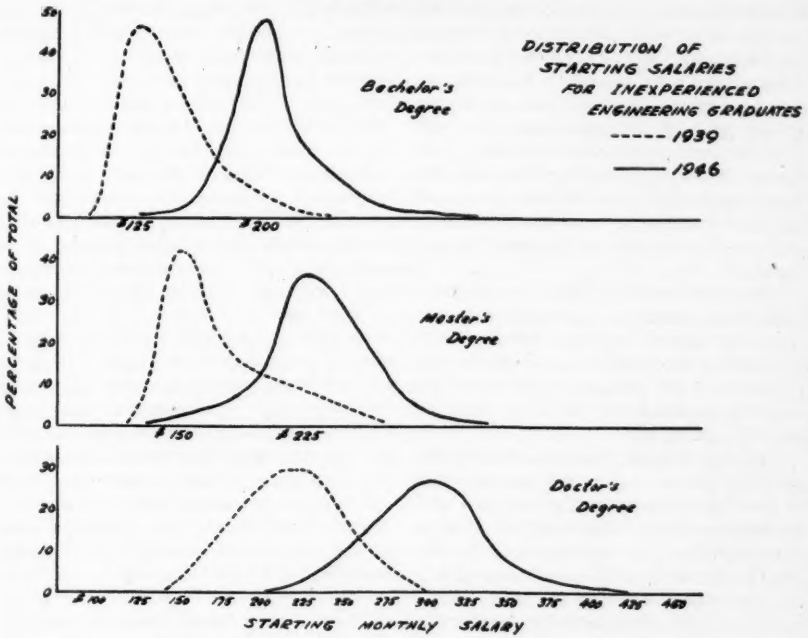
Total Employment of and Needs for Engineers

R Research and Development P Production, Management and Sales T Total

(Survey of 125 companies in April 1946)

		(1) 1938 Employment	(2) 1946 Employment	(3) Per cent 1946/1938	(4) New engineers per year 1938	(5) New engineers per year 1946 (6 mos.)	(6) New engineers per year 1947	(7) Per cent (6)/(4)
Aeronautical	R	266	1,198	450	78	313	382	490
	P	30	168	560	7	30	41	586
	T	296	1,366	463	85	343	423	498
Chemical	R	991	2,055	208	167	219	362	217
	P	1,099	1,863	170	137	94	246	180
	T	2,090	3,918	187	304	313	608	200
Civil	R	333	651	196	68	62	247	363
	P	1,415	1,087	77	87	59	150	173
	T	1,748	1,738	99	151	121	397	263
Electrical	R	2,864	4,047	141	251	205	675	269
	P	2,921	3,920	135	264	384	519	196
	T	5,785	7,967	138	515	589	1,194	232
Mechanical	R	2,369	4,373	185	383	479	749	195
	P	3,252	4,675	144	398	567	699	175
	T	5,621	9,048	161	781	1,046	1,448	185
Mining and metallurgical	R	144	221	153	33	47	75	227
	P	206	330	160	39	25	47	120
	T	350	551	158	72	72	122	170
Other	R	107	350	327	21	28	86	410
	P	380	618	163	43	52	74	172
	T	487	968	198	64	80	160	250
Total	R	7,074	12,895	182	1,001	1,353	2,576	257
	P	9,303	12,661	136	975	1,213	1,776	182
	T	16,377	25,556	156	1,976	2,566	4,352	220

APPENDIX D



APPENDIX E

Selected Comments of Personnel Directors

"Unfortunately, there are very few graduate engineers who have the necessary qualifications, aptitudes, and inclinations to work in development design. Many of our development men have no engineering degree, but do have generally a high school diploma and some specialized designing education to go with the natural aptitude. Locating and training young engineering graduates for development design with us are a continuous problem. We never have enough of these people, and we are not too hopeful that we ever will have."

"Our company has been expanding its facilities tremendously during the war and postwar periods, and according to present plans will continue to do so for two or three years at least. It is difficult to forecast whether or not further expansion and development will continue uninterrupted or whether it will be temporarily curtailed. Due to expansion problems, wage control, shortage of engineers, housing problems, and so on, it has been difficult to hold men; and we have experienced a particularly large turnover this year. We have employed and reemployed a large number of veterans, who have been responsible to no small degree for the high turnover. During the past few years we have lowered our standards for new technical employees. This fact may partially account for the large turnover. For example, we have employed older men, but in many cases could not justify as high salaries for them as we could for employees of the same age who started with us as young men. Many of these older men have been able

to get jobs elsewhere paying higher salaries because they were better qualified for the other work; or the work was not so permanent, and, consequently, higher rates of pay were justified. As engineers become more plentiful, we anticipate greater stability of employment, and we plan to limit employment to men with higher scholastic records. Naturally the future personnel requirements shown in the questionnaire are our best estimate, and may be subject to considerable variation."

"We have received numerous applications from technical graduates who entered the armed services directly upon graduation, and this in our minds has proved that the situation with regard to available technical men is not so acute as was first presented."

"By way of general comment, we might add that our most pressing current need is for qualified men in the research and development field. Our need for production engineers has been reduced by the men available from the ordnance plants that we operated during the war. Also, many of our veterans with production experience are returning from the armed services. However, the need for production engineers will increase during the next few years as the physical expansion of our manufacturing facilities increases."

"It is not possible to make even a reasonably accurate estimate regarding our needs for 'inexperienced' engineering graduates in the immediate future. The major reasons for this situation are (*a*) of the known large number of engineering employees who have not yet returned from the armed forces, the number who will exercise their re-employment rights is unknown; in many instances present engineering employees will be displaced by former employees returning from the armed forces, and (*b*) authorization for some additional major construction is pending. Following such possible additional construction, further appreciable reductions in the design and construction groups are anticipated."

"The number of additional inexperienced men needed each year for our organization beginning in 1947 must, of course, be only an estimate. The figures assume some replacement of engineers *but no large growth in technical personnel.* We have rather arbitrarily divided these estimated requirements between the major fields of engineering. The relative numbers of aeronautical and mechanical engineers, in particular, should not be considered as indicating corresponding specialization during employment. It is anticipated that the aeronautical engineering curriculum will be offered in more colleges and universities and that more men will be recruited from this field in coming years than in past years. It seems reasonable to assume, however, that more engineers will be required as specialists in the industry, with more opportunities for electrical engineers due to the increasing importance of electronics in the field of controls and instrumentation, and for chemical and metallurgical engineers due to the problems of materials development in connection with gas turbines and other advanced types of aircraft power plants."

"The survey which you are making should prove to be of considerable value, especially in view of the great interest in engineering education which has developed as a result of the wartime activities. Even though there might not be an excessive number of engineering graduates for some years to come, I believe it would be desirable for engineering students to realize that they would not necessarily be wasting the time spent in obtaining an engineering education if they did not get into technical engineering work. It has been my observation that a great many engineering graduates who are not following engineering are rather apologetic. I believe that for many business activities an engineering education is more valuable than letters in science and general arts education. If this attitude could be imparted to engineering students, particularly those in the lower part of the class scholastically who are least apt to follow engineering work, I believe it would lead to more satisfaction

on the part of the engineering graduates concerned and also tend to increase the number of engineering students."

"In the last six months we have been able to hire all the engineers we have needed and we are amazed at the large number of applicants both through letters and personal interviews that we have had for the few jobs open. Though this evidence would lead us to believe that scarcity in engineering personnel is not so great as we had feared, our picture may cover such a limited cross section of the whole national picture that it is misleading."

"The data representing our needs for additional inexperienced engineers in 1947 are our best estimate at this time. Undoubtedly as reconversion is completed and production goes into full swing, there will be a tendency for some of the younger men already employed to take other types of employment. Some of them will probably want to follow engineering pursuits more closely allied with technical training received in the armed forces, whereas others will probably shift to concerns producing much needed consumer goods. For these reasons we feel that while our *total employment may not change materially, yet the turnover in individuals may be large.* During 1945 we wrote the placement directors of the engineering colleges in the Middle West from whom we have hired engineering graduates in the past. We gave these placement directors complete information about our college graduate training course and asked them to have interested veterans write to us. *The response to this request has been more than enough to fill our needs for the present.*"

"At the moment we do not anticipate any immediate vacancies in the research division and have not indicated a need for additional inexperienced engineering graduates for the next six months. A number of our employees on military leave of absence have returned and others have indicated their intention of returning within the next few months."

"You have requested us not to include science graduates, and I therefore have left this classification out. At the present moment, however, this is our primary interest inasmuch as we are extremely desirous of securing men with advanced degrees in mathematics and physics."

"We noted that excepting for the last column, the information required referred only to engineering graduates. You undoubtedly appreciate that every organization has border-line activities which either engineering or science graduates might carry on. The sharp decrease in the number of electrical engineering graduates engaged in research and development is in part due to this factor. Also in recent years we have been fairly successful in filling engineering positions with 'almost graduates,' that is, men with three or more years of engineering education who had not qualified for an engineering degree."

"We are finding it extremely difficult to employ qualified engineers at present and assume that this will be the case for some time to come. This seems to be particularly true in the textile industry, where the importance of technically trained men is just beginning to be appreciated."

"If I were to estimate the probable technical engineering employment in production and sales which might logically be expected in our mills and their wholesale connections during the next few years, I believe that the totals given in our research and development activities might safely be multiplied by twenty."

"As to my personal judgment of the problem, it appears to me that the overall failure to speed reconversion has also retarded technical employment. But just as soon as industry generally is in full swing, we expect a shortage of technically trained men, particularly because there has been no incoming crop of technically trained men the past few years and also because many men are dropping out of industry to return to school for resumption of their education."

"It is our opinion that we will not have too much difficulty in meeting our require-

ments of inexperienced engineers because of the number being released from the armed services. We do, however, have considerable difficulty in locating experienced aircraft engineers. Those who are available are reluctant to move to another city due to the housing problem."

APPENDIX F

Significant Quotations from the Opinion Poll

1. "How do employment needs in the engineering department now (and prospective needs for the next year or so) compare with normal?"

   "Need for engineers today greater than normal. In next five years will require considerably more engineers due to greater specialization and expansion. Advances in characteristics of materials and of design too great for one individual to know to carry out complete design of a machine or part as he formerly did."

   "Need for engineers more now than in normal times. Need will be more in future due to greater requirements for labor-saving design. More emphasis placed on costs of production."

   "Employment needs in the engineering department are higher than normal now and probably will be for the next two years. This situation is a result of the tremendous task of reconversion to peacetime production. New products must be designed and developed to fill to capacity the increased production facilities that were added during the war. In addition to that, existing civilian products must be re-designed to apply the improved principles and techniques developed under the impetus of war."

   "Much greater than normal. During war years have hired and used non-graduates with some years of college training because could not get type graduate wanted. Now have a four year unfilled need which will attempt to fill as soon as suitable graduates are available."

   "This company is planning to use more engineers than ever before. Present plans call for increase of at least 30 per cent over normal. Due in part to establishment of new Technical Research Department for which building is now under construction."

   "The needs of this company for engineering graduates will be in excess of normal for next five years. Reason given is that none were hired during depression and none available during war period. Agreed that had graduates been available during past several years, present and future needs would be about normal. Older men in organization will make it necessary to hire young graduates. Interested in those under 27 years of age. Will not hire above that age."

   "Proportion of engineers should be greater in poor times than in boom times because that is when you are scratching to figure out new products with which to get new business. In future will need fewer engineers because items now being engineered will be in production."

2. "What is your opinion of the engineering graduates?"

   "In general the graduates are not very good. The students who went through the accelerated courses are not up to par. However, the men who were in the armed forces and returned to college are noticeably superior to those who lacked the service experience and are making a much better record in school and show greater possibilities."

   "Graduates have what we need from standpoint of technical knowledge. Can't be expected to have the practical training which we will give. However, we observe that for the most part they have no conception of the present labor situation and the part that labor relations play in running any business today. If I were to suggest any changes it would be to include some good courses in labor

relations, the history of the labor movement, a course in psychology, even a course in business accounting. A cardinal need in our business is for a young man to develop a breadth of vision."

"It is sometimes necessary to train these men to write their reports in good English."

"Graduate engineers in general have been well trained. It is suggested that, along with technical engineering training, they be given a certain amount of business and cost accounting training so that they may be better equipped to apply their engineering training to the actual running of a business."

"Of the opinion that during war time the grade of teaching was not as high as usual due to the fact that many of the best college professors were engaged in war work."

"Engineering graduates are considered good but no better than high school graduates with some engineering background together with actual experience on the job."

"Poor. Not as well prepared or rounded out as business and art graduates."

"Prima donnas are no longer desirable as research and development require teamwork."

"Engineering students lack practical perspective and application of technical training. Do not have conception of what is required in actual production in industry. There are some exceptions where student has worked in industry before or during school attendance."

"The average engineering graduate of today comes to us with a scope of knowledge that is too limited. He has spent four years wading through laboratory reports and memorizing formulae with too little stress on the fundamentals of mathematics, physics, mechanics, and chemistry. Therefore, when he is confronted with a problem that is not covered in one of his books, he is usually at a loss to derive his own formulae. In our opinion, the curriculum of the engineering college should be changed to give the engineer a better fundamental knowledge of the sciences with a program of teaching the application of that knowledge to problems in the field through actual work in industry."

"Engineering graduates in general are well prepared for industry but industry could profit by the students spending more time (perhaps a fifth year) in college. Industry, however, can overcome this deficiency by well planned and executed training courses during the graduate's first year of employment."

"This company definitely does not want the present graduate and will get their engineers from companies in the east such as R.C.A., General Electric, etc."

"There should be more emphasis on research work as a career, and attention to good scientific report writing and note taking than is now the case. There should also be more emphasis on the interpretation of data."

"Colleges are educating too large a percentage of engineers who do not have the qualifications to become engineers."

3. "What do you think of the cooperatively trained engineer?"

"In a number of cases, men who have been co-op students become oriented much quicker and have had a more mature viewpoint toward the job."

"The fellow who has had some practical experience—either partially worked his way through school or worked on industrial jobs summers usually gets the picture quicker. Many who come in with no work background expect more than they ought to expect."

"Cooperative plan is good. Industrial concern participating in such a

plan with a college or university should receive some remuneration for training the student during his working period. This cost should be included in the tuition fee. A graduate engineer is of little productive value for some time. He must receive training in the work of the particular firm in which he elects to work. A cooperative plan would provide part of this training during a student's school period. An objection might be that the school period would be lengthened out too much."

"Theory is fine but the application of the theory impractical due to the following: (*a*) Relations with labor unions would cause difficulty. (*b*) Use of students is very much limited to the city in which the school is located. (*c*) It is not adaptable to industries such as electrical utilities requiring long on-the-job training periods before the employee is fully productive."

"Likes them as they have practical viewpoint. However feels that cooperatively trained engineers do not have sufficient technical knowledge."

"We believe the idea is good, but that a cooperatively trained engineer needs more guidance."

"The idea is excellent. If followed, the maximum work requirement should be six months for the four-year college course. And the work that is done should be approved by the college and credited as a part of the course. More than six months of outside work in a four-year course will require too much attention away from engineering studies."

4. "In your observation has the war experience of manufacturing companies increased their dependence upon and use of engineers?"

"The war experience of manufacturing companies has increased their dependence upon and use of engineers. Many small companies that never employed a resident engineer in the past, now do so. In addition, many of the smaller companies are going to the engineering schools to secure the services of the men at the top of the class. Many coal companies are now employing engineers, whereas heretofore they depended upon electricians."

"Yes. Our jobs are more technical than ever before. Automobile and aircraft manufacturers are more conscious of close tolerance and fine finishes. Instead of accepting standard machines these companies want special machines designed."

"Definitely, yes. For example, the introduction of radar and other navigational aids require specialists in that field. Engineering and technical problems in all phases of shipbuilding are increasingly complex."

"Decidedly yes—particularly for the new sciences."

"Decidedly yes. Colleges and engineering societies have so well propagandized industry in general that the smaller industries must have an engineer on their payroll to do business with the larger industries."

"The jobs in their business have become more technical and therefore this company depends more upon and uses more engineers."

"Depend on engineers more than ever. Old-time inventors are passing out of picture and need is for young engineers with ingenuity."

"Increased use of engineers has resulted from the fact that their trained thought processes have steadied the thinking of other employees. Pure engineering or design, as indicated in the questionnaire, does not affect our product."

"Unquestionably yes. This is particularly true concerning research and development work, which is now and will be done much more extensively, thus requiring greater use of engineers."

"Yes in the sense that spiraling of

wage increases causes more mechanization."

"This is a utility business and rather than becoming more dependent upon engineers they feel that they should be careful not to take so many that there are not enough opportunities for advancement for them."

"More specialization is required to meet needs of considering weights and characteristics of materials and to reduce costs. More stress placed on time and motion studies and imagination in design."

"War experience of manufacturing companies has increased their dependence upon engineers. We have found that thoroughly engineering a product effects large savings by full utilization of all of properties of the materials going into it, as well as eliminating costly cut-and-dry procedures."

"Unquestionably so! This opinion is based upon observation and not from actual experience. The colleges cannot graduate enough engineers within the next five years to supply the demands of industry."

"The company plans to use engineers more extensively than ever before. For example, will try to place this year three engineers in Purchasing Department where none were used before. General Manager informed Employment Office he wanted all supervisory trainees to have engineering background either through college training or in outside industry."

"Not necessarily due to the war, business is now more than ever dependent upon technically trained men to be able to stay in the game at all."

APPENDIX G

Report of the Subcommittee on Technical Institutes

Technical Institute Education in Retrospect

Historical developments, evolutions, or even "revolutions" throughout the world have influenced current offerings in technical and engineering education. It is an interesting story, and an analysis of educational needs and offerings in the United States emphasizes the result of ill-advised planning, or the lack of planning, in the past, which is bearing fruit now in an inadequate as well as a spotty supply of technically trained personnel; a backsight is always easier to evaluate than is a foresight.

Beginning around 1800 a movement for the education of working men flourished for half a century with varying degrees of vitality, both in Britain and in America.

In Britain, this movement became the main stem in the development of technical education and has developed in 250 or more "local technical institutions" with a total enrollment far exceeding 100,000 men. The university arm of technical education was much slower in development and has only recently reached any numerical size.

In America, this movement, in its early stages, closely paralleled that in Britain through the establishment in the early 1820's of mechanics' institutes in our principal cities, and other schools were created to aid in disseminating scientific information among farmers and mechanics. As the years passed by and as a result of the influence of a number of factors, technical education of the college or university type became the main stem, reversing the results in Britain. Thus, the technical institute area of education gradually reached a low ebb in America by the 1920's.

As might well be expected, certain dominant types of schools have emerged and have stamped their character on great groups of institutions, but we have created nothing which resembles the carefully conceived and articulated national systems of technical education which have developed in Europe.

We have had the benefit of much unhampered pioneering and have been spared much narrow regimentation on the one hand, but on the other have permitted

broad gaps to develop in our American educational offerings. These gaps in the so-called "technical institute" area of education began to be rebuilt or repaired in the 1930's, but a bit late to meet the needs in World War II when the shortages of technically trained men proved costly to us as a nation.

Needs Yesterday and Today

At least seven separate studies of the technical institute area of education have been made in the United States since 1928, all by recognized organizations. It is outstandingly significant that all of them have generally agreed in all findings with one exception, and that is, each in order, based upon findings and analyses, has raised the ratio of technical institute men to four-year college men needed for the most effective results.

	Ratio of technical institute men to four-year college men
1929 S.P.E.E.	2.7 to 1
1943 State of New Jersey	4.4 to 1
1944 U. S. Office of Education	5.2 to 1
1946 Spot Checks	Nothing to indicate a ratio reduction

How an adequate supply of "technical institute" trained men might be made available is another question, since most developments of this character in the past have required rather long periods of evolution, and such a period appears to be developing since the late 1920's.

It is still generally felt by those more or less familiar with this area of education that certain statements made in the original Study of Technical Institutes, published in 1931 by the S.P.E.E., still are reasonable assumptions in the light of the many surveys made since that time. Of particular interest is a direct quotation, page 11, paragraph 12, of that report: "The actual needs and the potential demands are beyond the resources of voluntary and private agencies, although the latter have important contributions to make to the enterprises as a whole. The needs of the country could scarcely be met by less than 250 institutes, and seem to call for the creation of a great chain of community institutions having an organic place in city and state educational systems, yet free to achieve their own distinctive character. There appears to be no necessity for limiting these institutions strictly to the type of post-secondary education with which the present study is concerned. Secondary courses, if definite in aim and rigorous in character, as well as short unit courses for men with more limited needs, could probably be included in the scope of a technical institute, provided adult ideals and standards of work remain dominant. There are, in fact, a number of technical high schools for boys which could extend their work into the post-secondary field without serious difficulty. The essential thing, however, is that the technical institute shall be a distinctive type of institution with clear-cut purposes and specialized direction, and not tinged with the comprehensiveness of the present day high school."

Present Status of Technical Institutes

The Engineers' Council for Professional Development classifies technical institutes of the present day in the following eight groups:

(1) Technical institutes, endowed or publicly supported and operated on either full-time or part-time basis. Wentworth Institute, Ohio Mechanics Institute, and the Rochester Institute of Technology are examples.

(2) Junior colleges, publicly or privately supported, offering terminal programs, such as the Los Angeles City College.

(3) Evening sessions of colleges and universities, such as those of Drexel Institute and Pratt Institute.

(4) Extension divisions of colleges and universities, which offer work either by correspondence or in extension centers, such as those of the University of Wisconsin and the Pennsylvania State College.

(5) Proprietary schools, operated by private individuals or corporations, such as the Bliss Electrical School, Casey Jones School of Aeronautics, and the Capitol Radio Engineering Institute.
(6) Schools or training divisions operated by or closely related to industrial concerns, such as the Westinghouse Technical Night School and the R. C. A. Institute.
(7) Schools operated by divisions of government for specific purposes, such as the maritime academies.
(8) Correspondence schools, such as the International Correspondence Schools.

This classification will indicate the diversity of this type of institution and their programs. "In duration, courses range from a few weeks to two or three years of full-time work or to five or six years of evening school attendance; in variety of work, virtually the entire range of engineering and technical practice is included; in nature and level, programs verge upon skilled artisanship at one end of the scale and approach professional engineering education at the other." *

The characteristics of education of the technical institute type are given in the following paragraphs:

(1) The purpose is to prepare individuals for positions auxiliary to, but not in, the field of professional engineering.
(2) High school education or the equivalent is required for admission.
(3) The work is essentially technological in nature; it is based upon elementary principles of related physical sciences, requires the use of mathematics beyond high school level, and employs rational processes rather than rule-of-thumb methods of solving problems of design, construction, and operation.
(4) Programs are briefer, more intensive, and more specific in purposes than are collegiate engineering curricula, though they lie in the same general fields of industrial and engineering practice. Their aim is to prepare for specific technical jobs or lines of activity rather than for broad sectors of engineering.

The magnitude of education of the technical institute type in the United States is indicated by the following tabulation:

ENROLLMENT IN WORK OF TECHNICAL INSTITUTE TYPE, 1940–1941

Kinds of institutions	Number of individuals enrolled in courses or curricula
Technical institutes	8,400
Terminal programs of junior colleges	5,975
Evening sessions of colleges and universities	10,200
Extension divisions of colleges and universities	23,500
Proprietary schools	20,000
Schools operated for or by industrial concerns	2,500
The International Correspondence Schools (schools of technology)	81,225

A list which the Engineers' Council for Professional Development maintains for its own use includes 263 institutions in the United States which offer curricula in the technical institute field.

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* From the report of the Subcommittee on Technical Institutes, April, 1944.

Engineers: Wanted

By REGINALD C. PRICE

Assistant Professor of Engineering, New York University *

The technological innovations introduced by American science, together with the applications realized by engineers, have enabled the attainment of production goals, time and time again, that a generation ago would have been outside the reach of reasonable expectation. Basic research in the laboratory, then applied research and finally the effectuation of actual production through the know-how of the engineers; these are the stages through which the miracle of American production has proceeded. It is nothing short of incredible then that the United States alone among the major nations has shown little disposition to provide for the training of engineers on a basis at least as comprehensive as the pre-war level. It has not been surprising to see the "Engineers: Wanted" sign hanging out during the war, but it is surprising that full steps are even now not being taken to re-establish the flow of engineers into professional positions.

The steady and persistent reduction of the numbers of engineers undergoing training has been apparent both in the graduate schools and the undergraduate colleges. While the number of engineers receiving Ph.D.[1] degrees was nominal until 1927, between that year and 1941, a marked upsurge increased by more than six times the number of doctoral degrees annually earned in engineering. Then came the downturn. From just under 80 Ph.D. degrees in engineering granted in 1941, a precipitous descent to virtually none in 1945 has contributed to a shortage of highly trained men in engineering fields, men who are required for many positions in research activities of industry and government, on engineering college faculties, and in various other activities where the doctor's degree is increasingly becoming a prerequisite for employment.

The scarcity of engineers receiving doctoral degrees is charted by M. H. Trytten in *Scientific Monthly* (January, 1945) from which one can conclude that the deficit of engineering Ph.D's incurred up to and including 1945 amounts to over 400 individuals. Furthermore this shortage is cumulative due to the time required for refresher courses by those absent from the field for a year or two. On the basis of this chart, the deficit in Ph.D. engineers for the year 1945 alone will be more than 100 men, or nearly double the average annual output for the years 1936–1940.

The Bush Report[2] estimates that the probable accumulated deficit of men with engineering doctorates due to the war, will amount to nearly

* The writer is indebted to Dean Thorndike Saville, New York University College of Engineering, for counsel.

[1] The term "Ph.D." is used for all earned doctorate degrees in engineering fields, and includes Ph.D., Eng.D., Sc.D., etc.

[2] Vannevar Bush, "Science The Endless Frontier," July, 1945.

1,000 by 1955. This is a deficit which we may be unable to overcome, even by promptly embarking on remedial measures. Experience has shown that the deficits in the training of scientific personnel incurred as a result of war are usually not compensated by subsequent acceleration of the rate of training. Without some corrective steps, however, the consequences will be much more serious than they need be.

Nor are the deficits confined to those who seek to breathe the rarefied air of the doctorate. While the engineer has less occasion to advance to that degree than do those in physics and chemistry, the ratio of M.S. degrees in engineering to doctoral degrees in engineering is certainly not less than 5 to 1, having exceeded 10 to 1 in pre-war years. This would indicate a deficit of men with doctor's and master's degrees in engineering amounting to 6,000 by 1955.

Just as serious as the deficiency of engineers with advanced degrees is the impending shortage of men with their first professional degrees.

The number of men graduated by American engineering colleges increased from 3,000 in 1917 to about 15,000 in the academic year ending June, 1942. From this peak of nearly 15,000, the number of first professional engineering degrees granted to civilians fell off to less than 11,000 in 1943–44, and conditions led to a number of estimates that the number of bachelor's degrees awarded in engineering for the academic year 1944–45 would be only a fraction of normal.

The dean of a midwestern college of engineering reported[3] in April, 1945 his expectation that the number of civilian engineers graduated during that year would be less than 2,000 made up largely of individuals physically incapacitated. Later, estimates of 2,500 engineering degrees earned for both 1945 and 1946 were advanced. In another release[4] Dr. Linton Grinter, Illinois Institute of Technology, noted that only 2,940 senior civilian engineers had been enrolled in the fall of 1944, an ill omen when at least 100,000 additional engineers and scientists are needed if the country is to provide 60,000,000 post-war jobs.

Actually these estimates are low, apparently due to failure to recognize the impact of the accelerated program for the training of engineers and the full magnitude of the engineering training programs conducted in conjunction with the armed services. While it has been known that under the A.S.T. and N.C.T.P. training programs of the Army and Navy respectively, a substantial number of men were being given specialized training in engineering, the general impression has been that relatively few of these received sufficient academic credits to qualify for engineering degrees. There have been no figures available showing the number of engineering degrees granted to such students. Consequently arrangements were made to seek such information in conjunction with the annual survey conducted by the Society for the Promotion of Engineering Education. This circularization has shown first degrees granted in recognition of engineering work pursued under programs sponsored by the armed services (based on returns from 115 schools reporting, 48[5] of which had granted such degrees), as follows:

[3] J.E.E., April, 1945.

[4] *Engineering News-Record*, October 11, 1945.

[5] Of these 48, seven had A.S.T.P. units only; 33, N.C.T.P. units only; six both A.S.T.P and N.C.T.P.; while two had other training only

Year	A.S.T.P.	N.C.T.P.	Other	Total
1943–44 . .	203	1,205	98	1,506
1944–45 . .	285	3,085	85	3,455
Total	488	4,290	183	4,961

Allowing for this source of trained engineers, the number of first degrees granted in 1943–44 is increased from 10,600 to 12,100. For 1944–45, besides the 4,724 civilians reported to the society as having received first degrees, there were 3,455 others, giving a total of about 8,200 for the year. This is four times preliminary estimates. The figure of course presumes no duplication, *i.e.* that the 4,724 individuals reported to S.P.E.E. as graduates were *civilian* graduates as indicated on the questionnaire.

If we plot pre-war data (see Fig. 1 and Table 1) and project the trend that might normally have been expected had not the war interfered, we can obtain an approximate estimate of the deficit of trained undergraduate engineers. While a straight line trend represents the data acceptably, the projection of the trend is speculative at best. However, it seems reasonable to apply the trend curve within the period to 1948–49 as the best available, recognizing that definite limits are pertinent, predicated upon (1) number of future high school graduates, (2) percentage of high school students entering college and (3) proportion of college students accepted for engineering training. Economic conditions will naturally enter importantly into the above decisions. On the basis of the trend curve, we may reasonably conclude that by the year 1948–49, we shall be short some 21,000 engineering graduates, even assuming that Selective Service regulations are modified in the immediate future. The deficit incurred through 1945–46 will have mounted to nearly 14,000, a figure nearly three times the 1944–45 class of civilian graduates. Cumulative deficits subsequent to 1940 are shown in Fig. 2 and Table 2, allowing for slight surpluses

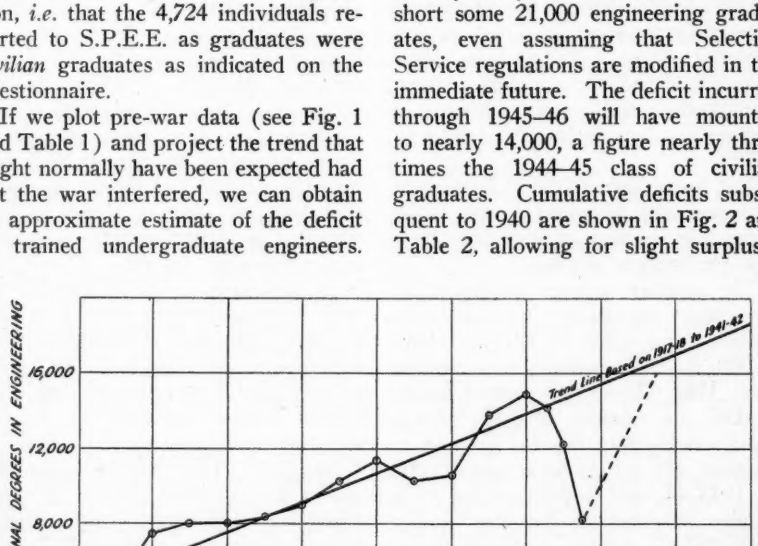

FIG. 1. First professional degrees in engineering granted in United States.

TABLE 1

TREND OF FIRST PROFESSIONAL DEGREES GRANTED IN ENGINEERING

Year	First Professional Degrees Granted in Engineering	Calculetad Straight Line Trend Curve
1917–18	3,079	4,400
1918–19		
1919–20	4,620	5,200
1920–21		
1921–22	7,358	6,000
1922–23		
1923–24	7,984	6,800
1924–25		
1925–26	7,977	7,600
1926–27		
1927–28	8,284	8,400
1928–29		
1929–30	8,947	9,200
1930–31		
1931–32	10,374	10,000
1932–33		
1933–34	11,421	10,800
1934–35		
1935–36	10,337	11,600
1936–37		
1937–38	10,577	12,400
1938–39		
1939–40	13,808	13,200
1940–41		
1941–42	14,847	14,000

Source of Data: Biennial Surveys of Education.

in 1940–41 and the two following years.

While this cumulative deficit predicted for 1948–49 is quantitatively less than that indicated by other recent reports, it is decidedly significant. The estimate of 55,000 reached by the S.P.E.E. Division of Administrative Officers [6] and the "rock bottom figure" of 50,000 suggested by the head of an eastern college of engineering [7] were developed without benefit of data on the number of civilian engineering graduates for the 1944–45 academic year. The latter's range of 75,000 to 150,000 submitted as estimates of the cumulative deficit to 1950, is however subject to question, particularly in view of the likelihood that increased reliance on engineers by industry is already reflected in the trend curve through the data of the last two decades.

Reflecting the same lack of national foresight as the record with respect to graduates the civilian enrollment in professional engineering schools in 1944–45 was only one-third what it was in 1940–41. The enrollment in 1944–45, about 35,000, was the lowest since 1917, the time of World War I.

This willingness to jeopardize the technological future has been in striking contrast to the practice of other nations. For example, in Canada, while the picture is not entirely clear on the basis of very incomplete data, it appears that both engineering enrollment and number of first engineering degrees granted increased in wartime, while both declined sharply in the United States. Number of first engineering degrees granted at the University of Toronto, largest engineering college in Canada, increased from 157 in 1938–39 to 203 in 1943–44, an increase of practically 30 per cent. At Purdue, in the same period, the number of first engineering degrees conferred held about even, falling from 531 to 526 (Data from J.E.E.).

The engineering enrollment data reflect the same sort of situation in sharper relief. In 1936–37, four major Canadian engineering schools had an enrollment of 1,744 which increased by 43 per cent to 2,490 in 1944–45. Over the same interval, total enrollment in United States engineering colleges dropped from 67,569 (for 118 institutions) to around 34,000 (for 136 institutions), or to substantially one-half. While there has been some evidence of an inclination to overestimate the

[6] J.E.E., November, 1945.
[7] J.E.E., January, 1946.

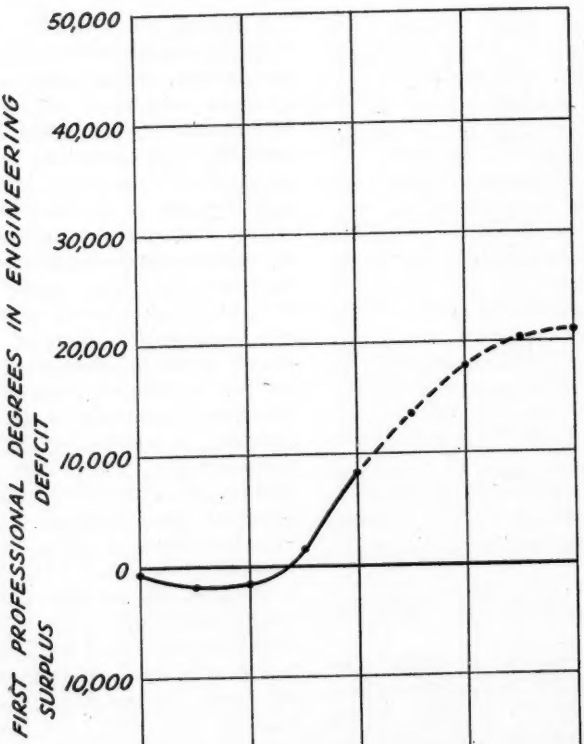

FIG. 2. Cumulative surplus or deficit as calculated from straight line trend, first professional engineering degrees awarded in United States.

TABLE 2

DEFICIT IN NEWLY-GRADUATED ENGINEERS BASED ON STRAIGHT-LINE TREND CURVE

Year	First Degrees Expected as Based on Trend Curve	First Degrees Granted					Deficit Based on Trend Curve	Cumulative Deficit
		Civilian	Under A.S.T.P.	Under N.C.T.P.	Under Other Programs	Total		
1940–41	13,600	12,709	—	—	—	12,709	+891	+891
1941–42	14,000	14,847	—	—	—	14,847	+847	+1,738
1942–43	14,400	14,145	—	—	—	14,145	−255	+1,483
1943–44	14,800	10,612	203	1,205	98	12,118	−2,682	−1,200
1944–45	15,200	4,724	285	3,085	85	8,179	−7,021	−8,220
1945–46	15,600	7,000*	—	3,000*	—	10,000*	−5,600*	−13,800*
1946–47	16,000	12,000*	—	—	—	12,000*	−4,000*	−17,800*
1947–48	16,400	14,000*	—	—	—	14,000*	−2,400*	−20,200*
1948–49	16,800	16,000*	—	—	—	16,000*	−800*	−21,000*

* Estimated.

relative differences between the engineers trained in the United States and those in Canada, it is clear that the differences *do* exist.

The sources from which industry, engineering school faculties, and research laboratories can draw trained engineers needed for reconversion and for post-war operations, are extremely limited. There are civilians who are exempt from military claims for physical reasons; some veterans who have been honorably discharged, but who have had no formal training; other veterans who have had some engineering training under civilian auspices; and professional engineers released by the armed services, war industry, the Army Specialized Training program, or the Navy V-12 program; there are obstacles, however, which interfere with the steady flow of men from all of these groups. Civilian students enrolled in engineering schools as of April, 1946 are still being inducted by Selective Service as they become 18 years old, unless they are physically unfit for military service. The number of 4-F's available is inconsequential in the light of the need and some discharged will require from three to four years before they can receive the bachelor's degree. Many veterans who have had A.S.T. training or some pre-induction college training in some cases will be able with a year or two of additional college work to secure their first degrees. While Navy men who have gone through the V-12 program will in many cases become available after a still shorter time in college, the date of their availability is likely to be longer deferred. Navy men, mainly subject to a four-year enlistment period, can be retained by the Navy so that they will not at once become free for civilian activity. The number to be released by the Navy in the next year or two is not yet clear.

The reservoir of those who had completed the engineering curricula of the Army Specialized Training Program contained about 7,820 as of June, 1945, not including men who had entered the program with engineering degrees. The potential engineering students were

engineering degrees awarded in United States.

divided as follows among the several curricula of the A.S.T.P.:[8]

Chemical Engineering	200
Civil Engineering	1,286
Electrical Engineering	2,469
Mechanical Engineering	1,943
Sanitary Engineering	359
Miscellaneous	1,563
Total	7,820

As indicated above, only some 488 men of this group had received degrees by June, 1945. It has been estimated that at least one additional year of academic training will be necessary in order to qualify the rest of this group for an engineering degree.

Table 3, which follows, shows the number of men trained under the Army Specialized Training program from its inception through June, 1945, excluding those who had engineering degrees prior to entry on the program.

In addition it has been estimated that a total of 3,600 men would be trained in the A.S.T.P. program between July 1, 1945 and December, 1946 in the Civil, Electrical and Mechanical Engineering curricula. There is therefore a reservoir of approximately 11,000 men who have had A.S.T.P. engineering training, and who have not received an engineering degree. With the operation of the educational provisions of veterans' legislation, it seems reasonable to estimate that possibly 8,000 of these may enter engineering colleges and receive their degrees between 1947 and 1949.

The corresponding number of trainees receiving Navy V-12 work has been estimated at 12,000[9] including those completing their training through November 1, 1945. Possibly 4,500 will have received first degrees. The proportion of the rest which will become available to the profession for 1949 is problematical, but possibly 5,000 may come in this category.

The apparent deficit to 1949 of enginers with their first professional degrees amounts to 21,000. Even allowing for 8,000 men coming up from the AST program and 5,000 from the Navy V-12 program, there still remains an estimated net deficit as of 1949 amounting to some 8,000 engineers.

How can this shortage of professional

TABLE 3

ARMY SPECIALIZED TRAINING PROGRAM
ENGINEERING GRADUATES OF
THE A.S.T.P.
12 APRIL 1943–30 JUNE 1945

Curriculum	Term Completed	No. of Graduates of A.S.T.P.*	
Chemical Engineering	7	200	
Civil Engineering	6	1,053	
Electrical Engineering	6	1,130	
	7	1,339	
Mechanical Engineering	6	1,578	
	7	365	
Sanitary Engineering	7	145	
	8	214	
			6,257
Miscellaneous			
AES–1	6	146	
AES–2	4	328	
AES–3	4	537	
AES–4	4	463	
AES–5	4	89	
			1,563
Total			7,820

* In most cases *not* graduates of engineering colleges. All men entering A.S.T.P. work with first engineering degrees are excluded. Data furnished by School Division, Army Service Forces, on July 5, 1945.

[8] Data furnished by School Division, Army Service Forces.

[9] On basis of data provided by Field Administration Division, Bureau of Naval Personnel on July 17, 1945.

engineers be alleviated? Several answers have been noted by interested engineers and scientists. In a large measure the solution to this perplexing problem lies in a better utilization of man power already trained, plus improved immediate provisions for training of new blood. The most serious shortages to be met are those of 1946 and 1947.

Sometime ago Charles L. Parsons, Secretary of the American Chemical Society, reported, according to the *Chemical and Engineering News,* that the classification officer addressing a company of basic trainees at Camp Sibert, Alabama, made this statement:

"I know that there are many chemists and chemical engineers among you who hope that they will have an opportunity to do research or technical work in the Army. I must assure you that the Army has about 100 times as many chemists and chemical engineers as it can possibly employ in such capacities, since most of the research work requiring chemists or chemical engineering is well taken care of, mostly by civil servants."

It is this situation no doubt that is responsible for the statement that 15,000 chemists and chemical engineers in the armed services have been doing work which bore no relation whatsoever to their professional training. There is reason to assume a similar situation in other engineering fields. With ten million men under arms it would seem to have been a wiser policy during the war to search out the mere handful of professional scientists and pre-professional students in the ranks and furlough them either to industry or to civilian preparation for engineering and science rather than to waste their talents in the armed services performing the routine tasks of camp life or their lives in combat.

The fluid nature of the factors affecting the shortage of engineers makes difficult at this time the drawing of estimates as to when, if ever, the deficit of engineers will be overcome. The uncertainty as to the renewal of the Selective Service act, the doubts surrounding the intentions and staying abilities of returning veterans who now feel they should secure engineering training under governmental provisions, the question as to physical limitations of plant and faculty that confronts the engineering schools, the difficulty of predicting the economic climate and the strength of the lure of jobs that may attract potential engineers away from their training, all these are pertinent and will rceive attention by those interested in finding means to reduce the deficit as rapidly as practicable.

The engineers who have adapted the scientific developments of this technological age to practical use, the men who with consummate skill have added the "know how" to the scientist's laboratory answer, are in high demand. Several measures are needed to alleviate the immediate shortage of trained engineers and to restore the normal flow of men through academic channels. Formulation of those recommendations however is beyond the scope of this paper.

The Engineer's Father

By THOMAS J. MacKAVANAGH *
Professor of Electrical Engineering, Catholic University of America

It has been said: "The child is the father of the man." In the cradle, the child of the engineer is indistinguishable from the child of the butcher, the baker, and the candlestickmaker. Even in high school,—given equally good mothers—boys are boys, without distinguishing labels to mark the engineer's son as different from the son of the lawyer.

Looking back, upon graduation from high school, the boy sees that he has had to steer his course—with the help of his mother—through a society in which he found the ambitious and the drifter, the honest and the cheat, the soft voice and the megaphone, the gentle and the rough neck, the clam and the rooster, the religious and the irreligious and non-religious, the firm friend and the Judas, the greasy grind and the scanner, the leader and the hanger-on, and many other contrasting types. Looking ahead, there are fifty years or so of his being an employer or an employee, as head of a family or as a solitary bachelor, as being with or without means, as being a leader or a cog in a machine, as being of firm opinion or as shaping his sails to current opinion, as being honest or doing that which is expedient and so on.

Should he take up law or medicine he will still be intimately in touch with society analyzing its moods and its ills and trying to bring order out of chaos. Upon graduation he shall have the legal right to hang up his shingle and practice law or medicine, and he shall be welcomed by society as a friend and not as a stranger. Specialization will come after a mature consideration of tastes, abilities and opportunities. Although graduating with the same degree and passing the same bar examination the corporation lawyer becomes miles apart from the criminal lawyer in his knowledge of specific laws and procedures, and would have good reason to be worried if asked to take a sophomore law examination.

A middle-aged M.D. told me he knew nothing of his anatomy below the collar, and another said that the territory above the navel was foreign to him, and that a recent graduate was treating him for a foot infection.

The boy who enters an engineering school may find teachers who would ask him to forget the social implications of the past and the present so that he may devote all of his time to forming a shell about himself to be duly labelled "Power," "Communications," "Industrial Applications" and so on, even in one department. When he sticks his head out of his shell at commencement he finds he has little in common with his

* I happen to be a D.C.L. and a member of the bar, and somewhat annoyed by the constant reference to the legal profession, by engineers and educators, as the perfect ideal. It is about time that the engineers began sounding their "A" and then singing their own praises in harmony. We have too many one-man quartettes prone to singing the blues, and it about time for us to line them up in an engineer's glee club.

high-school chums who are now M.D.'s or Counsellors-at-law, and he envies their grip on themselves as part of the social order.

He may have grave doubts about their having the moral right to do so, but there is no denying the legal right of his former high-school chums to practice their professions of law and medicine. Where does he stand? Has he the legal right to call himself an engineer? Grey-haired specialists who could not pass a sophomore examination if suddenly asked to do so tell him he is not much of anything, he is totally unprepared to swim in society, and, anyhow, no one knows what an engineer really is.

A panic-stricken group tells him we must do something to raise the profession of engineering up to the level of the legal and medical professions, and their association with these professions may be of the dent-fender or belly-ache variety. It is enough for them, however, that the fellows who—not so long ago—became counsellors-at-law within three years after graduating from high school have the legal right to engage in practice, and are members of a powerful group that have life and property in their keeping. Little thought is given to the many years of apprenticeship after graduation, the many years of continued education, and of the many who were starved out of the profession because they lacked the personal qualities required in given situations.

So, let us begin at the beginning. Let the shell about the young student of engineering be thin enough so that he has the same chance to break through that a chicken has. Do not ignore the implications of his previous social experiences but, instead, help him to develop in understanding the things that torment society. Help him to see the possibilities in the paper-hanger before the paper-hanger compels him to become a G.I.

After four years of hard work and passing under the eyes of his teachers in an acceptable manner he should have as much right to call himself an engineer as the lawyer has to call himself a lawyer. He is not yet quite sixty and do not expect him to become sixty overnight.

He is no more a menace to safety and property than the young lawyer is, and he is much less likely to foment domestic quarrels, to encourage litigation, and to be the mouth-piece of the criminal.

Give the youngster a fair start as an engineer as a member of a dignified profession—dignified in every good interpretation of the term. He can be just as critical of himself as he was of his teachers, and he knows that he has still the task of educating himself to be worthy of a position of grave responsibility. He is a member of the one profession that is outstanding in producing orderly citizens, for it is a rare event to find the engineer accused of crime.

It is not generally understood that when we subtract forty from sixty the answer is sixty and that the eyes of sixty cannot see the graduate of forty years ago. It is enough that we wish him well and help him to see through the eyes of sixty when he is sixty.

So, let us graduate young *engineers,* and welcome them as members of a great profession, and as men who, in time, will add lustre to the profession.

When they reach middle-age they may know little about what is below the collar. And, why should they not honestly admit that they are not omniscient?

The Half-Educated Engineer

By BALDWIN M. WOODS

Professor of Mechanical Engineering and Director of University Extension, University of California

Out of every 100 men who reach age 65, 15 are self-supporting—the other 85 are dependent. Of the 15 who are self-supporting, 9 continue at work; the other 6 are able to retire on their accumulations or on annuities accumulated for their benefit. This is the report of an insurance company in the late '20's. It gives a financial picture of what for the moment I shall call the half-successful man. Without stopping to note more than the indication this gives of the poor managing ability of the average man in his own affairs, I pass to other measures of success.

When is a man half-educated? When he knows half of the facts, principles, theories and practices of his profession? In this sense, no one is probably more than one-tenth educated. When Dr. Thurston wrote a notable essay on the half-educated man some years ago, he emphasized the half-grasp of knowledge, the trouble of a man who never really knows anything. He just half knows it. But I am more concerned at the moment with other questions of half education than those here mentioned—the quantity and quality questions which were raised by Thurston.

As of today, the engineer is half educated when he leaves college. Consider first the question of time. He has been under supervised training for about 16 years—age 6 to age 22. During this time, if his education has been sound, he has experienced a transition of responsibility. In the beginning, self direction of his learning program was limited to a small area. With the passage of the years he has assumed larger and larger direction of his own training—with the collaboration of his schools, let us hope—until at graduation he is prepared to assume direction —not merely of his professional life, but of the continued training he must give himself. What will he do with the next 16 years? And perhaps the 16 years following? And what will his alma mater do to lend a hand? Is the engineering graduate the forgotten man of the College of Engineering? No matter how desirable it is for a man to be independent—to direct his own affairs—it is inevitable that he call for help from his associates and from the institutions of society. Our engineering graduate of today requires services provided by his alma mater which he may utilize as he finds need. Thus, the engineering extension service today is directed first to the needs of the man who has been to college. As he leaves the institution with a diploma, no matter how well earned, he must not close the books on education, even of the supervised kind.

I once remarked to a colleague that a small child has so much to learn. I was impressed with the large amount of information which the children of

my neighborhood were supposed to have and which in many cases they did have. He replied, "So much to learn —he has everything to learn." It is almost this way with the man just out of college. Grounded in theory, initiated into practice, he is a neophyte in the profession. Even if he is accomplished in the profession, he will find in the course of 10 or 20 years that the things he does differ in approach and technique from the way he learned them in college or first practiced them in the field. A man who closes the books on study as he gets his diploma has missed the basic challenge of education. Learning must be lifelong.

An engineer may also be half educated in combining the scientific and professional aspects of his calling. His college can give him a great deal in the way of scientific background. It can give him only an intimation of the profession of engineering. He must learn among other things that engineering was an art before it was a science. It is no accident that some of the greatest engineers of the Renaissance were men like Leonardo da Vinci in whom it was difficult to tell whether the artist or the engineer predominated. In the engineering faculty of every good institution there is a balance between the engineering scientists and the professional engineers. In the simplest terms, the engineering scientist reaches into current developments in the basic sciences and brings from these developments applications for the use of engineering. From the point of the practicing engineer, they are still theoretical. From the point of the pure scientist they are highly applied. Research partakes of this dual characteristic. Nearly all of it is applied from one individual's point of view and basic from that of others. The professional engineers in the faculty know the practice of engineering and its needs—in industry, in government, and in human affairs generally. They are proficient in giving an intimation to the young engineer of what to do with what he knows, of how to meet the demands of a situation. For a young engineer, highly proficient in the skills of the college, to be equally proficient in the demands of the profession, he must treat himself as half-educated. He must analyze his assets and capabilities, and even more the demands of the profession. Great professional engineers often develop out of students who were more or less unknown for scientific ability. When great scientific and great professional ability are combined, the result may be superlative.

There is also the relationship to society—to the civilization in which one lives. Here is where we engineers even now are obviously half-educated. We have made great progress in one respect; we now recognize that the engineer may use his training to advantage in managerial and governmental jobs. This was of course demonstrated during the war. But even prior to the war, engineers were consulted by governmental agencies on major policies. These were not merely policies of design or of structures, but of the need for and utilization of, the structures for the benefit of the communities in which they were placed. During the war, of course, some agencies, like the War Production Board, had a majority of the top administrative posts filled by engineers. There is no doubt that the engineer from now on will have abundant opportunity to serve in solving problems which we usually designate as those of technology and society.

There is of course much current dis-

cussion of nuclear energy and its role in civilization. Many of our scientists and engineers are expressing strong convictions as to the need for a change in political philosophy. Some are even so bold as to indicate the ways in which society needs changing, and in effect to lay out a diagram for such changes. I suppose that most scientists of today would agree that there is no world problem more important than the manner in which nuclear energy is to be utilized. Those with whom I have discussed the subject are agreed that this is more important as a problem than that of immediate further development of knowledge of the phenomena themselves. Can the engineer expect to act as expert in this applied field? Can he assume himself to be an expert in economics, government, education and business? As I see it, the point at which he must become educated is that of his role in these affairs, relative to the role of those who are themselves experts in the fields mentioned. Isn't it alarming to have engineers voice very strong beliefs in economics or business or education or government, when one discovers on further study that they have never paid the price of becoming experts? Isn't it a little presumptuous for us as engineers to ask the full respect for our profession if we are unwilling to give the same respect to those in others? Isn't it contrary to fact to suppose that progress is possible only in engineering and science—that the same statement of principles that was valid a century ago will solve without modification the problems of economics, government, education and business? If one can judge by the past 20 years, rapid changes are taking place in all of these fields as well as in engineering. The engineer must become educated in his relationships to the experts in other fields, making the contribution of which the world is in great need. He must, however, recognize that a field like economics is not necessarily known to him simply because it is commonly discussed by engineers, business men and educators, most of whom have not paid the price to become experts in it. In other words, the role of the expert in one field working with those in others is involved. Isn't it likely that the methods of engineering if applied to this task of collaboration will yield results of which all the professions can be proud?

Finally, there is the phase of education which Woodrow Wilson used to discuss with students at Princeton. He entitled this "When a man comes to himself." A man discovers himself as an individual—a person—in this world of affairs; a man with a philosophy of life and an understanding of people, gifted perhaps with a vision of what better human relations may be. David Starr Jordan talked about this as one of the great reasons for being educated. He said, "Only the educated man is good company for himself." Obviously a man spends his life with himself. The importance of this need for self discovery is the reason for stressing the humanistic stem in engineering training. What we sometimes overlook is the fact that at best only a little can be done by the time one is graduated. A great English thinker in adult education has questioned whether the undergraduate is sufficiently interested in self-improvement and social movements to justify expenditure of much undergraduate time in courses in the humanistic field. One should at least get a start, but the bulk of the job will remain for tackling after graduation.

One does not multiply these factors of one-half in order to show that at graduation a man is only one-sixteenth educated or less. The student has done the biggest job if he has learned to take charge of his own education. The war demonstrated how rapidly men could learn new things. Doubtless men had learned formerly to meet educational challenges quickly, but the process had never been made so graphic. It is said, for example, that one hour a day for two years will make a man proficient in a foreign language. Less than that will give him a good start. The challenge to the engineering college and to its graduates is to get together. Since the needs of the graduate will go far beyond the field of science and engineering, a broad service, university wide in scope, is called for.

Some men have made admirable use of these aids in the past. A young man came to my office about 15 years ago. He was a regional engineer for a large technical organization, nation-wide in activity. On graduation from high school he had gone to work at once and had become a practicing engineer without benefit of the usual 4-year curriculum. He had decided that he must fill in the gaps. And so he wished to take his degree while working on his job. One of my colleagues, expert in advising such students, laid out a 2 year program of mathematics and physics for him to undertake by extension, principally in correspondence courses. All of us promptly forgot about him, because many start and few finish. However, in 6 or 8 months he appeared again. With difficulty I recalled him, but when he showed me completion certificates in all of the courses which had been assigned to him, with grades of A and B, I recognized the quality of the man. Several of us joined in laying out further work and in planning concessions in the regular degree requirements to allow for the training not easily measured by college courses. He continued in his studies. Some 2 months later however he came in and appeared perturbed. By this time we knew him. When I asked the trouble, he stated that he had just been made chief engineer of his company and was obliged to move to Pittsburgh, his new headquarters. He believed that it would no longer be possible for him to pursue his studies and that he would perhaps have to give up the thought of getting his degree. This was a disappointment. What would you have said to him? I said, "The world has today conferred upon you the degree of engineer. It is the supreme alma mater. You have lots to learn, of course, but from now on, direct your program to meet your higher professional needs—not the list of courses prescribed for undergraduates. Your goal is that of the great professional engineer. Men with your spirit will not be half-educated."

The Profession of Engineering—A Definition*

By GEORGE L. SULLIVAN
Dean, College of Engineering, University of Santa Clara

Webster defines a definition as:

"A description of a thing by its properties, or of a conception by its attributes; a brief explanation of the meaning of a word or term; such an account as intelligibly relates the idea defined to analogous or related ideas. Formally, a definition consists of a statement of the class in which the subject of definition is included, and an enumeration of the differentiae, or specific marks or traits, which distinguish it from other members of the same class. A definition is adequate or exact when the differentiae make certain the identification of the object intended."

Locke says:

"Definition being nothing but making another understand by words what the term defined stands for."

Josiah Royce says:

"Definition, simple positive, hard and fast as it is, never tells the whole truth about a conception."

My task is to make you understand what the expression "Profession of Engineering" stands for. I cannot expect to do this completely. Words are an imperfect medium for conveying thought. I cannot expect to convey to you exactly what I am thinking. Your thoughts cannot possibly be exactly the same as mine and, even if I could, I would not wish to deprive you of the pleasure and profit of adding your contributions and side lights to my ideas. I will, however, have to enumerate many differentiae to distinguish the "Profession of Engineering" from other professions and from other activities which are not professional.

Engineering has been defined in many ways. One of the oldest definitions is that of Tredgold who in 1820 stated that:

"Civil Engineering is the Art of directing great sources of power in nature for the use and convenience of man."

One of the latest definitions is that adopted at a conference of representatives of national engineering organizations, held in New York City on August 28, 1945. This definition is an attempt to state a definition which can be applied to licensed or registered professional engineers with the approval of the courts. The definition used in many of the license laws was held by some courts to invalidate the laws. The definition adopted at this conference is:

"Definition—Professional Engineer." "The term 'professional engineer' within the meaning and intent of this Act shall mean a person who, by reason of his special knowledge of the mathematical and physical sciences and the principles and methods of engineering analysis and design, acquired by professional education and practical experience, is qualified to practice engineering as hereinafter de-

* Presented at the Pacific Southwest Section, S.P.E.E., Berkeley, February 22, 1946.

fined, as attested by his legal registration as a professional engineer."

"Definition—Practice of Engineering." "The term 'practice of engineering' within the meaning and intent of this Act shall mean any professional service or creative work requiring engineering education, training, and experience and the application of special knowledge of the mathematical, physical and engineering sciences to such professional services or creative work as consultation, investigation, evaluation, planning, design, and supervision of construction for the purpose of assuring compliance with specifications and design in connection with any public or private utilities, structures, buildings, machines, equipment, processes, works or projects. . . ."

This definition is intended primarily to provide a legal definition of engineering but in many ways it fails to outline the broad field of engineering and it is tautological in that the definition includes *engineering* as the application of *engineering science* without defining engineering science. It does mention mathematical and physical science and omits to mention the sciences of economics and psychology. Yet every engineer must consider the cost of his designs and the returns which they will produce, and he must consider the effects that will be produced on the users of the designs and the methods that must be used to induce people to build the designs.

I propose a definition, the idea of which is not original, although I have not seen it stated in exactly these words:

"ENGINEERING IS THAT PROFESSION THE MEMBERS OF WHICH DESIGN AND OPERATE STRUCTURES AND METHODS BY WHICH MONEY, MEN AND MATERIAL ARE USED TO CONVERT NATURAL RESOURCES INTO FORMS WHICH ARE USEFUL TO MAN."

This definition lists four elements which are essential to engineering:

ENGINEERING IS A PROFESSION.

ITS MEMBERS DESIGN AND OPERATE.

THEY USE MONEY, MEN AND MATERIALS.

THEY CONVERT NATURAL RESOURCES INTO FORMS USEFUL TO MAN.

PROFESSION

A profession is a calling or occupation which is based on special knowledge of fundamental laws and whose operation benefits mankind. This classification eliminates such semitechnical men as surveyors, draftsmen, laboratory technicians, time keepers, material checkers, and plant operators from those who should be classified as engineers. It requires that the engineer be well educated in the sciences which he must apply and that he is able to make decisions based on reason rather than on precedent or empirical information.

DESIGN AND OPERATE

To design is to build something, not in visible form, but in the mind. The designer builds a machine or a bridge in his mind with the hope that it will some day be expressed in visible form. Other things than machines and bridges may also be designed. The sales manager just as truly designs a sales campaign as the engineer designs a bridge. The sales manager builds the campaign in his mind, he sees every detail, each advertisement, he plans each sales talk. In this planning he may be guided by a profound knowledge of economics and psychology. This does not make him an engineer. This is not engineering design because it is not for the purpose of changing a natural resource into a form useful to man.

The operation of a maintenance de-

partment in a shop may be an engineering job or it may not be engineering. In the traditional shop, when a lathe broke down the foreman called the maintenance department and reported that a lathe was down. The maintenance superintendent said to one of his men: "Bill, go over to building six and get that lathe running." That is not engineering, it is not design. In a modern organization, that lathe would have been inspected periodically. It would have been kept in working order until its cost of operation was greater than the cost of operation of a new lathe. It would have been replaced when its economic life was ended and the determination of that useful life would be by fundamental economic laws. The break down of a lathe in this organization is just as truly a failure of a design as the break down of a bridge is a failure of a design. This organization is an example of design which is truly engineering design since its purpose is to change a natural resource into a form useful to man; to change iron ore, or the refined metal, into some usable machine.

Just as a maintenance department can be designed, so a working force can be designed and a strike is evidence of a failure of a design or the lack of a design. The engineer cannot change the resources of nature into forms useful to man without the aid of other men. This requires the design of an organization which will function smoothly and produce desired results. Frederick W. Taylor was a famous engineer and his reputation rests largely on his designs of human organizations which were used in the conversion of natural resources into forms useful to man.

But neither machine designs nor organization designs operate themselves. It may require as much planning and as much understanding of fundamental laws to operate a design as it does to originate the design and such operation is definitely engineering when the purpose of the operation is to convert a natural resource into a form useful to man. This whole problem of operation is included in industrial engineering, or production engineering or management engineering; whatever you wish to call it.

Money, Men and Materals

Everyone recognizes the fact that engineers deal with materials but I think that the above discussion makes it clear that the engineer is always concerned with money, and with men as well as with materials. The engineer must spend money to obtain machines and he must hire men to operate them or he will never convert natural resources into forms useful to man. Furthermore, if his designs cannot be built cheaply or cannot operate economically they cannot be built at all and the engineer cannot accomplish the object of his profession.

Conversion of Natural Resources into a Form Useful to Men

A typical example of this is the mining of iron ore, the refining of the ore, and the manufacture of an automobile engine from the refined ore. In its natural state the ore cannot perform any function which is of use to man. Engineers make plans to dig the ore from the earth, to smelt it, to refine it, to work the resulting metal into the parts of an engine and to assemble these parts into an engine which can be used by man to produce useful power. In planning this series of processes, it is necessary that the engineer use the fundamental laws of geology, chemistry, physics, mathematics, economics

and psychology. He will not do the work himself and it will not be done unless he can buy machines and hire men to do the work. He must use money, men and materials and apply them scientifically to the task to be accomplished. So we come back to our proposed definition:

"ENGINEERING IS THAT PROFESSION THE MEMBERS OF WHICH DESIGN AND OPERATE STRUCTURES AND METHODS BY WHICH MONEY, MEN, AND MATERIALS ARE USED TO CONVERT NATURAL RESOURCES INTO FORMS USEFUL TO MAN."

This definition does not mention civil engineering, or electrical engineering or research engineering. It recognizes the fact that there is a profession of engineering and that we need not separate it into many divisions. It would be better if we did not do so. If such a definition as this were generally adopted by state licensing boards it would be a great forward step toward the clarification of the term "engineer." It would also be a step toward the recognition of the engineering profession for what it is and what it should be.

The New England Section of the American Society for Engineering Education will hold its fall meeting at Norwich University, Northfield, Vt., Saturday, October 5, 1946. An invitation is extended to all who may be in New England at that time.

Carlton E. Tucker, Secretary,
New England Section, A.S.E.E.

A Practical Guide to Engineering History Sources

By HAROLD LANCOUR
Librarian, The Cooper Union

Some years ago The Cooper Union installed its new Director in a colorful ceremony. In his address on that occasion Dr. Edwin Sharp Burdell committed the institution, over which he was to assume control, to that educational philosophy which he called Scientific Humanism. After pointing out that it was not the academic humanism of Erasmus but rather the "dual interest of Leonardo and Goethe in art and science" that he was speaking of, Dr. Burdell went on to discuss the place of scientific history in this concept of engineering education. "The history of science," he stated, "goes hand in hand with the political and artistic history of man. Science is systematized positive knowledge. The history of science is the only history which can illustrate the progress of mankind because achievement of positive knowledge is the only human activity which is truly cumulative and progressive. Perhaps it is more necessary than ever to insist upon this at a time when irrational forces dominate in many places, and the progress of rational thought—which is the basis of any culture—is jeopardized." *

Members of this society have often observed men or women coming up for the first time to look out over the great intellectual panorama spread out before them and how tremendously excited they are by its spectacular immensity. You also know how a good teacher will often canalize that enthusiasm into some scholarly activity that the student finds enriching and enlarging. Under stimulating leadership and with the steady cooperation of the faculty and staff, the students' natural interest in the great cultural stream and the place of their own age in it can be nurtured and encouraged.

That is precisely what happened at The Cooper Union. Within a short space of time the Library staff began to have questions, fairly searching ones, too, concerning the many aspects of scientific and engineering history. Books that had not felt the touch of an inquiring hand for decades began to move from the shelves. Without letting the similes get too out of hand, one librarian swears it was just like having some great sleeping giant awakening as the stirring and flexing went on back among the book stacks. It was a pretty exciting business.

So many unusual and surprising things turned up that need was felt for a careful survey of the collection for historical material. It was begun and worked at, intermittently, for several years. Finally Harold C. Whitford, Engineering Librarian of The Cooper Union, became interested and completed the compilation early this

* Cooper Union for the advancement of science and art, New York. . . . Proceedings of the installation of Edwin Sharp Burdell, the sixth director of the Cooper Union, November 3, 1938. N. Y., Pandick Press, 1938, pp. 28–29.

year. The list of titles has just been published and appears as Number 28 of the *Cooper Union Bulletin,* Engineering and Science Series, and is entitled "A Guide to the Literature on the History of Engineering." The list is specifically a selection of 629 titles to be found in The Cooper Union Library and designed to be a guide to students of that school who are working on term papers in the general field of engineering history. As a carefully selected bibliography with many evaluative and descriptive annotations, it will undoubtedly be useful in many other ways; as a means of evaluating the material in other libraries, as a guide for developing collections in this subject area. The simple but effective subject classification used will be of interest to librarians, and the three indexes, historical, author, and subject, which Mr. Whitford devised, are additional useful keys to the material covered.

Professor Tenney L. Davis of the Massachusetts Institute of Technology has contributed an eminently readable introduction that is a concise, tightly-packed, meaty summary of the scope of engineering history. Dean George F. Bateman of The Cooper Union was a most suitable choice to write the preface, for his interest in the study of the historical and biographical aspects of engineering has stirred the imagination of many generations of students.

Copies of the bibliography have been sent to libraries of the institutions accredited by E.C.P.D. and other libraries throughout the country. A limited number are available for distribution to members of the Society upon application to: Librarian, The Cooper Union, Cooper Square, New York 3, New York.

Address of Welcome*

By MONROE E. DEUTSCH

Vice-President and Provost, University of California

The University of California is happy that it has the opportunity to welcome you for your discussions in the field of engineering education. We trust that your deliberations may be fruitful. For the importance of engineering, its study and its research, has been revealed most vividly to our people in the glare of war.

Yet that very fact is adding mightily to the problems of the schools and colleges of engineering. The three-fold combination of the release of millions of men from the armed forces, the financial aid of the G.I. Bill, and the entry into colleges on the part of the students who were kept from study for four or five years, places a heavy burden on all phases of university work. The flood is pouring into colleges and universities over the entire land. And the only obvious dam is to be found in the dearth of housing. That, however, is no real solution since a potentially brilliant student may fail to find a room whereas an inferior student may succeed.

But even this in all probability will not so reduce the numbers as to permit us to accept all who may come and meet our requirements. And Engineering in all colleges will doubtless have to join Medicine and Jurisprudence in selecting from among the throng of applicants.

This is one of the greatest responsibilities that any human being or group of human beings can bear. Failure to admit a student may deny him the opportunity to fit himself for engineering in any institution. For example, if refused admission in the university supported by his own state, a student who is not a veteran may be financially unable to go elsewhere. Moreover, as selection is likely to take place in many institutions, the candidate may readily find barriers blocking him in a host of colleges. To all this you and I have no objection provided only we can be sure of a system of admission that will really select the most promising from the entire group.

This means that you have doubtless concluded that an important function of such a society as yours is the continuing study of methods of selection and no less of the success of these methods.

Aptitude tests, grades in courses leading to engineering, interviews—all these should be observed over a period of years.

The importance of the interview cannot be denied, but it is not everyone who is qualified to conduct it so as to get the best results. One must always remember that the student to whom admission is most important, is likely to be most nervous and anxious. The boy who comes from a home of wealth and who knows he wears the right clothes will be more at ease than a poor boy in shabby attire. These are but

* Presented at the Pacific Southwest Section, S.P.E.E., Berkeley, February 22, 1946.

the external difficulties handicapping the interviewer. There are yet greater ones in seeking to find out what kind of a boy you are dealing with—and this means the whole boy, not merely his brain or his hands.

Certainly while ability to succeed in Engineering courses as demonstrated by grades in them is important, exclusive reliance on them is undesirable. I am sure we could without difficulty find cases of men who have made great successes in the profession but whose grades were mediocre. After all, the challenge of the actual problem in life may serve as a great stimulus. And surely a ruthless elimination of students on the basis of a slight deficiency early in the college course when they are getting adjusted to collegiate education is not the answer.

However, it is unfortunately true that there are personal traits which are of the highest importance in every field, but which are by no means always revealed in any of the ways just mentioned. Pertinacity, honesty, endurance, ability to work with others—these are but a few of the traits which may make the difference between success and failure in any field. At times they may prove more important than mathematical or scientific ability. We shall have to secure the help of the psychologist who, I am sure, is by no means ready to say that he is today qualified to answer such questions.

Sometimes one finds that when a given method of selection is established, those in charge of the school or college measure its success by the grades of the students who had been thus chosen, in the courses in that particular collegiate unit, as for example in the case of medical students by their grades in anatomy, physiology, and biochemistry. That, I am certain you will agree, is not the ultimate test—the test is one that must take into account the success of the individuals in their professions. Society is interested in securing the best possible engineers, physicians, lawyers, teachers; it is not concerned primarily with the academic record of those in college or university. To be sure, the academic record plays an important part in determining success in life—but we all know it does not by any means tell the whole story. And it is the method of selection that will be most likely to produce the most successful engineers in actual practice that we are interested in attaining.

It should be as objective as possible; it should take into account only probable value to society—not wealth, important connections or any of the other factors that may insidiously enter into decisions.

At best it is not easy—but we cannot delay, for the tide has risen so high that we must act. Indeed the steps that we must take may well prove highly desirable, since, if well handled, they may deflect those who should not study engineering from attempting it. The very success of engineers has undoubtedly played a considerable part in leading hordes of students into this field. The selection of the wheat from the chaff is one of the most important responsibilities resting on such an organization as yours, for engineering education cannot be promoted if it is smothered by a throng of students of mediocre talent and promise.

I trust that your sessions may indeed contribute to the making of better and ever better engineers.

Problems in the Development of Technical Institutes in California*

By RALPH J. SMITH

Head, Engineering Dept., San Jose State College

Introduction

The technical institute on the college level is relatively new on the Pacific Coast and the school with which I am connected is very new in the field. To date we have graduated very few persons from programs of this type. However, discussions with administrators of schools, both in California and in the East, which have been operating over various periods of time have shown that the problems which we now face are of universal importance.

I should like to discuss some of these problems with you with the thought that formulation of a problem and presentation to a group of interested minds are big steps toward a solution.

Review

The background of the present system of engineering education is significant. As an outgrowth of the Industrial Revolution, there began about 1800 a movement for the education and welfare of working men. In Great Britain this finally resulted in technical schools having a total enrollment of over 100,000. (This can be compared to a peace-time engineering-college enrollment of around 10,000 in the United States.) The more scientific, university-level technological training was much slower to develop.

In the United States there were mechanics institutes in the major cities in the 1820's. The advent of the railroad led to a period of rapid industrial development and a corresponding demand for engineers with scientific training. Rensselaer Polytechnic Institute introduced a four-year professional course in civil engineering patterned after the higher technical schools of France and paralleling the curricula of the well-established arts colleges.

This plan was the basis of the university system. It was given stimulus by the Morrill Act of 1862 which made possible the establishment of the land-grant colleges in the less-wealthly western states. Engineering colleges were standardized and became the dominant form of training with recognized degrees and credits. Many technical schools became engineering colleges. Carnegie Institute of Technology, Worcester Polytechnic, Brooklyn Polytechnic, Cooper Union, Drexel Institute, and Armour Institute became four-year, degree-granting colleges. In the 1930 S.P.E.E. report Pratt Institute is described as "founded with clearly visualized aims and directed by men of tenacious purposes." It is characterized as "The most successful example of the two-year engineering school."

* Presented at the Pacific Southwest Section, S.P.E.E., Berkeley, February 22, 1946.

Since publication of that report Pratt Institute has gone from a two-year course to a three-year and then to a four-year program for reasons that will be discussed later.

In the course of the investigation which led to the 1930 report, it appeared that the technical institutes deserved special study. A grant for that purpose was made available and the results of the study are included in the report. The significant findings were these.

1. The number of technicians trained at this level did not begin to meet the demand. A comparison of the number of persons with non-degree training required by industry to the number of graduate engineers required showed ratios of from 3:1 to 5:1 in favor of personnel trained less than four years.

   A conservative estimate indicated a need for 50,000 graduates per year as compared to the 1,000 being trained in 1928.

   It was estimated that not less than 250 institutions would be needed to satisfy the demand.
2. The positions obtained by technical institute graduates were highly satisfactory with regard to salary and responsibility. Data were given on 1,100 two-year electrical graduates as compared with 1,100 four-year electrical engineering graduates and 5,000 four-year engineering college graduates of all courses. The median earnings of the three groups show no significant differences for the first five years and even after fifteen years out of college, less than $200 separate the annual salary of the four-year and two-year electrical groups. For a group of 3,500 two-year graduates one out of three became an engineer, assistant engineer, superintendent or manager.
3. The graduates were well satisfied with the training they received. Out of a group of 750 graduates, 90 per cent said they would go to the same type of school if they had to do it over again and 90 per cent said they would take the same course.

In considering these conclusions, I think it is necessary to take into account the fact that the data are based on graduates from 1894 to 1928. It may be that this was a period when the proporation of degree-holding men was quite small. If so, then the technical institute represented a relatively high level of training in contrast to its present position.

Problems of the Technical Institute

A. Getting Recognition from Employers and Labor

By definition of the E.C.P.D., the aim of the technical institute is "to prepare individuals for specific technical positions or lines of activity rather than for broad sectors of engineering practice."

To me, this means that there must be jobs toward which the training may be directed. Industry must recognize the superior ability of the graduate of a technical institute over that of a student from a vocational school or technical high school. (Actually, it might be expected that a technical institute graduate with intensive specialized education might be worth more to his first employer than an engineering graduate who comes with capacity to learn rather than ability to produce.)

This has not been the case in California. There is no general recognition by industry or civil service of any

training intermediate between the high school diploma and the college degree. I am told that only in rare cases have the unions given any recognition in the form of credit on apprentice time for advanced preparation. As a specific example, in areas where work on refrigeration and heating and ventilating units is controlled by the steam fitters' and sheetmetal workers' unions, the graduate of a three-year program in air conditioning finds it almost impossible to obtain employment without serving a long apprenticeship.

On the other hand, some companies have definite policies against hiring specialized personnel above the trade level. The chief engineer of a large oil company told me that since his company was in a new, highly competitive field the primary need was for men who could think, who could make original contributions. On that basis they were justified in putting men with four years of scientific training into many jobs which could be performed with only a minimum of technical preparation.

The technical institutes are handicapped by a lack of standardization in courses, certificates and nomenclature in general. Graduates of similar programs are called engineering aides, technical aides or technicians depending on the school. The employer tends to require each school to prove itself to him before receiving any consideration. The E.C.P.D. accrediting program may be helpful in this direction.

B. Getting Students into the Courses

There appears to be inherent in American citizens the desire for a chance at the top. Students do not want to enroll in a program which offers anything less than limitless opportunity. This is particularly true of returning servicemen who are for the first time in several years free to work out their own destinies.

The college degree is a recognized mark of social accomplishment. Also, it is becoming a real asset as more and more positions have a college degree as an automatic requirement. Especially is this true as industrial administrators become predominantly degree holders themselves. The use of college training as a factor in securing a preliminary screening of applicants is an unjust but widespread practice. For illustration there is the case of a western airline company which raised its college requirement for pilots from one to two and finally four years. Undoubtedly there is a positive correlation between academic training and general behavior habits, but certainly no one would suggest college life as the best way to spend four years in developing steady nerves, muscular coordination and discerning eyesight.

The professionally trained person on the average will receive a better salary than the technician. However, the idea that going to school will automatically increase one's earning power may be fallacious because the top-salaried positions are supervisory and administrative rather than highly skilled. I can quote figures which apparently show that if an electrician were to decide that he wanted a higher paying position and worked toward that end by going to an engineering college for five years and obtaining a masters' degree —that if he then entered the teaching profession in a California State College, it would take him over twenty years to catch up with his earnings as an electrician assuming no raises in union pay in that interval. And this does not take into account the $500 a year that it costs him or the state for training.

This failure to recognize that four years of training is a large investment is particularly widespread in a state such as California where the state provides high quality, tuition-free education. In eastern localities where every additional year's tuition must be justified, one- and two-year courses have been more popular. The part-time evening courses where for seven or eight years an individual can spend two or three evenings a week at a few dollars a unit have been patronized continuously.

The powerful influence of the parents is entirely different in a highly industrial community as compared to metropolitan areas of California. There is a different viewpoint as to what constitutes success. A skilled mechanic encourages his son to obtain training which will enable him to become a foreman. However, a $200-a-month office worker who is in charge of a group of filing clerks and stenographers may not recognize a $400-a-month foreman's job as representing a suitable goal for his son.

Again the lack of a consistent nomenclature makes it difficult to interest a student in a specialized course. He is not able to connect the suggested program with activities he has read about or discussed with acquaintances. By way of contrast, "engineering" and "engineers" have been given credit for everything from Casey Jones' ride to the atomic bomb.

Attempting to operate technical institute-type programs alongside university-type curricula is bad for the more intensive training. Invariably, the shorter program becomes a salvage course for those who cannot succeed in the academic training. This is probably one reason for the poor showing of some California junior colleges which offer pre-engineering curricula and technical courses. The technical courses are avoided because of the stigma attached to those enrolled.

C. Curricula Design

The problem of curricula design is probably simpler for the technical institute than for the engineering college. The training is to fit specific jobs. The requirements of those jobs can be analysed and the course constructed on the basis of the analysis. Rochester Institute, for example, through its office of Educational Research has done an excellent job of course design.

As mentioned before, there must be close contact between instructors and industry. The methods and instructional equipment must be those in use in industry. The excuse that "the theory is the same" may justify out-of-date textbooks and the obsolete equipment of the engineering college; but where the student learns to operate by operating the circumstances must be similar.

D. Course Administration

From the standpoint of the administration there are certain problems. The student in this type of program learns better by doing than by reading. There is more laboratory activity and less dependence on textbooks. The equipment is expensive and, as indicated before, it must be representative of modern commercial practice. Where reading material can be used information presented with the proper viewpoint is seldom available and the instructor must prepare his own.

The instructors must have practical experience and teaching ability. Where schools are tied to higher institutions because of accrediting needs, teaching

credentials involving credit for "education" courses are required. Finding an experienced man with teaching ability who has found opportunity to secure a teaching credential and who is immune to the call of industrial salaries is no small problem.

In addition, for this type of instruction small classes are necessary and the ratio of instructors to students must be high.

Summary

In looking over the technical institute situation we find a series of paradoxes. In the S.P.E.E. report industry indicated a demand for graduates 50 times the supply. On the other hand, here in California labor and industry are slow to recognize the institutions and credit the training.

It was shown that graduates earn good salaries and attain good positions. However, students avoid the more specialized courses on the grounds that they want a chance at the top.

Graduates said that they were well satisfied with the courses and the type of training. It is my experience that students are reluctant to enroll.

The report indicated that many more technical institutes were necessary to meet the need. We see that many schools are finding it necessary to become four-year engineering colleges and there are few new technical institutes.

Personally, I believe there is a place in the California educational system for training of this type. I think these problems can be solved. Those of us who are interested in the development of technical institutes will appreciate your help.

Conference on Emergency Problems in Higher Education

Washington, D. C., July 11–13

Emergency Problems in Higher Education were considered in a three-day conference held in Washington, July 11–13, under the auspices of the American Council on Education, with 150 representatives of governmental agencies, educational associations and institutions participating.

The first day was devoted to a series of presentations by fourteen leading figures in government and education, defining the problems. On the second day six round table groups examined the major problems in detail, viz., Higher Education of Veterans, Housing and Other Construction Problems, Surplus Property Disposal, Manpower Problems and Selective Service, Army and Navy College Training Programs, and Foreign Students and American Students Abroad, seeking solutions and formulating recommendations to be acted upon at the general session on the concluding day. President Truman received the conferees in his office at noon on the first day and addressed them briefly.

The resolutions adopted in the concluding session pledged the institutions of higher learning "to fulfill the responsibility placed upon them with professional zeal and with patriotic spirit," but also called attention "to certain inadequacies as to housing, educational buildings and teaching facilities which are so momentous as to jeopardize the prompt admission and adequate instruction of many prospective students—veterans and non-veterans."

Recommendations were made on many specific measures:

(1) *Education of Veterans.*—Optional acceleration, full utilization of facilities both day and evening, exclusion of subjects not germane to well-planned programs, simplication and reduction in number of reports to official agencies, consideration of aptitude, ability and maturity as factors in admission, and a uniform formula for charges under public laws 16 and 346.

(2) *Housing and Other Construction Problems.*—Amendment of FPHA regulations to assist veteran students, appropriation of additional funds under the Lanham Act, relaxation of minimum construction standards, passage of S. 2085 by Congress before adjournment, passage of S. 1770 as amended to provide Federal aid in the construction of permanent educational facilities, and the appointment by ACE of a small committee to cooperate with NHA and FPHA on operation problems in veteran student housing.

(3) *Surplus Property.*—Continuation and expansion of donation programs of the Army and Navy, and adoption of a nominal price policy on surplus property handled by the War Assets Administration.

(4) *Manpower Problems.*—Deferment under Selective Service for college teachers in fields of critical short-

ages, efforts to raise instructional salaries and intangible inducements to a level competitive with industry and government, and immediate action on S. 1850 providing for a National Research Foundation.

(5) *Army-Navy Training Programs.*—Approval by colleges of nominations to ROTC staff appointments, inclusion of staff members in regular faculty rosters, support of measures to enable the Federal government to provide more adequate physical facilities, approval in principle of the Army ROTC plan, and endorsement of the Holloway plan for the education of Naval officers.

(6) *Foreign Students and American Students Abroad.*—Acceptance of as many foreign students as is compatible with the present situation, reciprocal expansion of study abroad by Americans as conditions improve, endorsement of the Fulbright Bill to provide funds for foreign students through sales of surplus property abroad, and support for the cultural and educational program of the State Department.

Immediately following the conference public announcement was made of the appointment by President Truman of a national commission to deal with specific problems of higher education. The conference, no doubt, served as an unofficial exploratory medium for the commission's guidance. The American Society for Engineering Education was represented by Past-presidents H. S. Rogers and W. E. Wickenden. President Blake R. Van-Leer of the Georgia School of Technology and Dean Elmer Hutchisson of Case School of Applied Science were included among the speakers at the general sessions.

(Submitted by W. E. WICKENDEN,
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An Opinion on the Training of Teachers in the Humanities

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SYNOPSIS

The present methods of graduate training for teachers of English and the humanities in the engineering college are inadequate if not pernicious. Through undiscerning imitation of some of the methods of the scientist, many graduate students of the humanities have also acquired the major shortcoming of the scientist, specialization, and hence are ill equipped to teach effectively in an engineering college.

Despite the danger of fostering dilettantism, a broader species of training to develop a talent for generalization, interpretation, and evaluation should be promoted. Specifically, the taking of courses, largely *undergraduate*, in either or both the engineering college and the liberal arts college should provide the training needed. Such a program should encourage the recruitment and foster the development of the kind of teacher needed in the engineering college; but it should not serve as an impediment to such research as interest and ability may prompt the candidate to undertake, as an antidote to dilettantism.

Veblen's definition of sabotage as "the conscientious withdrawal of efficiency" seems to apply to many of the proponents of the pending or recently accomplished change in engineering education. For many of those who are the most zealous advocates of the humanizing of engineering education are likely, in the long run, to accomplish through neglect as much damage to the cause they have espoused as those who have attempted to defeat it by either indifference or hostility.

The truth is, not only the humanistic additions to the engineering curricula must be scrutinized, but also the training of those entrusted with effectuating that program. At just the moment when engineering educators are slaying the fatted calf—their scientifically weighted curricula—and preparing to welcome the prodigal son, a hue and cry is being raised against him in the camp where he has in the meantime been residing. For at probably no time in history have the critics of liberal education been more outspoken than today; never have the content of courses and the methods of training teachers been subjected to such searching criticism. The question, then, is: Can engineering educators afford to take over uncritically a system which even its sponsors recognize is in need of improvement?

Surely none will quarrel with W. E. Wickenden's declaration apropos the tasks of teaching the humanities, that "We do not justify our position if we relegate these responsibilities to routine teachers or men of unimpressive intellectual attainment," [1] and that "competent, sympathetic, and resourceful

[1] "Engineering Education After the War: Humanistic-Social Stem," J. ENG. ED., Vol. 35 (Sept., 1944), p. 46.

teaching personnel can be found, or if not at once available, that it can be developed." [2] Similarly, one contemporary critic of liberal education avers that humanistic studies at the undergraduate level "call for teachers with vitality, with broad esthetic and cultural interests, with sharpened critical faculties, with far-ranging intellectual curiosity." [3]

The Effects of Graduate Training

Here, however, the similarity ceases. Let us hear how Mr. Wickenden proposes to recruit and develop his humanistic faculty:

> At this point it is hard not to pick a quarrel with the graduate schools over their preoccupation with the minutia of historical and critical investigation to the exclusion of interpretive scholarship. Still one seeks in vain for a satisfactory alternative to the Ph.D. discipline for the young teacher of humanities in an engineering college. Lacking it, he is in danger of becoming an Ishmaelite without standing in the scholarly world and thereby frozen for life to a minor teaching role.[4]

Then observe what Mr. Millett has to say about such training:

> Graduate education in the humanities is much more likely to send out into undergraduate teaching men with low vitality, narrow interests, naive esthetic and critical judgments, and an intellectual curiosity that is either non-existent or is limited to a very narrow corner of the field the teacher has been tilling.[5]

What is shocking is what the graduate school does to the human material with which it works. On the whole, I should be willing to defend the proposition that most of the men who complete their work for the Ph.D. degree are less vital, less broaded-minded, less humane, more narrow in interests than they were when they entered the graduate school.[6]

Were this an isolated opinion, which it is not,[7] it would be less significant. But surely if "it is therefore the duty of faculty members who hold humanism in high esteem to use their influence and intelligence to counteract the tendency to measure a man's worth by the number of degrees he possesses," [8] engineering colleges need not genuflect before the icon of the doctoral degree. It is to be hoped that, in his desire to be practical, Mr. Wickenden did not expose the humanistic program to worse hazards than those of Ishmaelitism in the world of scholarship. In fact, as it is largely the purpose of the present writing to demonstrate, Mr. Wickenden's willingness to compromise with those who insist upon the indispensability of the Ph.D. degree may well preclude the attainment of the very goals he has proposed—may accomplish the elimination of many likely candidates and the emasculation of the interests and philosophy of those who survive the ordeal.

Surely, if the colleges of liberal education themselves are beginning to question the present value of the doctoral discipline, the engineering schools need not lag in setting up their own programs for the development of teachers. Belatedly, the engineer has conceded that he has too long been contented with the music of his slide rule, and he has invited the devotees of the

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[2] *Ibid.*, p. 47.

[3] Fred B. Millett, "The Rebirth of Liberal Education," New York, Harcourt, Brace, 1945, p. 22.

[4] Wickenden, *op. cit.*, p. 47.

[5] Millett, *op. cit.*, p. 22.

[6] *Ibid.*, p. 21.

[7] *Cf.* Hoyt Hudson, "Educating Liberally," Stanford University Press, 1945, p. 111: "Specialized graduate work can be liberalizing; but as things are, it usually is not."

[8] Millett, *op. cit.*, p. 143.

harp and the lyre to enter his sacred precincts. But if he admittedly erred in previously restricting their activities, he certainly has no reason for countenancing less than dulcet harmonies from them now.

Graduate Training and the Scientific Method

In "An Open Letter Addressed to the Dean of an Arts College," H. A. Basilius, describing the pangs accompanying the birth of a creditable, integrated course in the humanities at Wayne University, mentions

> the thing that has been and still is wrong with the teaching of the humanities, namely, the ossification and snobbery of the teacher who fails to digest and coordinate and interpret for human enrichment the tremendous heaps of knowledge and insight created and gathered by the Nineteenth Century, and who permits the heaping to become an end in itself.[9]

And in "Teacher in America," Jacques Barzun comments:

> Time was when no one in an American university had any doubts about the uses of research. Everyone was as busy as a bee bringing back to the hive his load of distilled information. Learned societies and periodicals absorbed and distributed this mass to those hungry for it —fellow scholars in the four corners of the earth.
>
> But for some time past, doubts have been expressed. "Knowledge for what?" asked Robert Lynd in a forthright series of published lectures.[10]

The source of this passion for the fact-finding type of research is obvious. Impressed with the efficacy of the fact-finding techniques in the sciences, emulative researchers in the humanities overlook the interpretive and comparative function of all worth-while scientific research. Thus there is little doubt that the misdirection given graduate work in the humanities is the consequence of the application of the scientific method to that field.[11] Whether this application is a perversion of the scientific method is perhaps unimportant; a true scientist would shake his head at many of the practices of those who attempt to assert their kinship to the scientists by "objective" methods directed towards meaningless goals—but no matter. What does matter is this: slavish imitation of the scientific method does not guarantee the worth of the labor expended nor the value, or even the utility, of the outcome.

At this point, of course, the social scientists can be heard spluttering. Wanting to eat their cake and have it too, they covet the appellation of scientists; and so they adopt one of two means of insuring themselves positions among the select group. They may extend their definition of science to cover any activity based upon a principle "as true to fact as it is indispensable to sentiment"[12]—a definition that excludes nothing except the flimsiest type of scholarship. Their reasoning is simple: because scholarship based upon error is obviously unsound—unscientific—they assert that all accurate scholarship must be scientific. Or they may insist that science is "motivated by *values* sought and won."[13] Few

[9] H. A. Basilius, *Journal of Higher Education*, Vol. 16 (Nov., 1945), p. 428.

[10] Jacques Barzun, "Teacher in America," Boston, Little, Brown & Co., 1945, p. 312.

[11] Millet, *op. cit.*, p. 18.

[12] Bronislaw Malinowski, "A Scientific Theory of Culture and Other Essays," Chapel Hill, U. of N. Carolina, 1944, p. 13.

[13] Judson C. Herrick, "A Liberal Education," American Association of University Professors' *Bulletin*, Vol. 31 (Autumn, 1945), pp. 348–356.

scientists themselves will substantiate this claim; and one need only observe the mountainous accumulations of data in every scientific field to see how doubts may be entertained on this score. For every scientist who attempts to interpret and evaluate the results of research, there are a hundred—a thousand—others who are industriously snowing him under with new facts. True, the value of no fact can be judged at the moment of its discovery; but if it lies buried under an avalanche of adjacent items, and no one but the janitor in the library ever dusts it off, what's the good of it? The matter may sound like the old argument about the definition of sound, but here we are forced to say—if no one hears it, it does not exist.

Moreover, if all of science is characterized by the pursuit of values, how does it happen that, in view of the possible perils attendant upon the release of atomic energy for peace or war, there are a number of research workers dubiously shaking their heads even while they, like masochists picking at a wound, tamper with the forces in the atom that may make a funeral pyre of earth?

In this connection it is interesting to note Ortega's comment:

> The internal conduct of science is not a *vital* concern; that of culture is. Science is indifferent to the exigencies of our life, and follows its own necessities. . . . Accordingly, science grows constantly more diversified and specialized without limit, and is never completed. But culture is subservient to our life here and now, and it is required to be, at every instant, a complete, unified, coherent system—the plan of life, the path leading through the forest of existence.[14]
>
> . . . culture requires that we possess a complete concept of the world and of man; it is not for culture to stop, with science, at the point where the methods of absolute theoretic vigor happen to end. Life cannot wait until the sciences may have explained the universe scientifically. We cannot put off living until we are ready.[15]

While they are asserting their kinship to the scientists, some humanists should be reminded of certain differences, other than that of method, between the humanistic and scientific disciplines.

One need only recollect Launcelot's dilemma in his relations with Guinevere, for instance, to be reminded how queasy are the foundations of ethics; and politics, economics, sociology, psychology, philosophy—all are alike in this respect. How attitudes toward polygamy, contraception, abortion, and infanticide can change in different areas according to the availability of food, the status of technological advance, and the pressure of the population! The scientist, on the other hand, is under no moral compulsion to make his theories jibe. If it is convenient to regard light as a radiation, he does so; if not—then he may resort to the quantum theory. Yet even such vagaries are rare; the establishment of scientific law in the light of existing knowledge is usually universal; whereas in the humanities, claims and counterclaims without number are filed, and the doubts of a few really reputable critics may never be downed.

It would do a number of humanists good to be reminded, moreover, that the cardinal sin in the field of scientific investigation is not error but the closed

[14] Jose Ortega y Gasset, "Mission of the University," trans. by Howard Lee Nostrand, Princeton, Princeton University Press, 1944, p. 84.

[15] *Ibid.*, p. 84.

mind. Jokingly, scientists aver that it takes a hundred years to disprove a scientific fact; as hypothesis succeeds hypothesis, it may even be said that all scientific advance is built upon error. Without the unjustified (or at least undemonstrable) assumptions of Euclid and Newton which made progress possible, there would have been no Einstein theory—in fact, there might have been no Einstein. Yet those humanists who venerate the scientific method are usually more outraged by an error in fact than by a poverty of ideas or inutility of labor; such bold apprentices as might attempt a *rapprochement* between disparate learnings are stymied by the training to which they are subjected in graduate school—a training which too often regards impeccability as the highest virtue.

Specialization

Regardless, then, of whether the scientific method has been correctly applied in the graduate school of the humanities, one thing is clear: the specialization which has resulted *is* a consequence of the scientific method.

Now it is specialization which has occasioned the severest strictures in analyses of our methods of graduate training—if not of our concept of man's role in society. "The dismembered man," as Lewis Mumford terms the specialist, "whether an engineer or workman, as organizer or salesman, needs less directive insight and intelligence once he is geared to the whole machine than the carpenter or weaver needed in his workship."[16] That specialization leads to the improvement of the race but degrades the individual, is Hegel's view. And although it is true that scientific advance rests upon the work of specialists, Tead questions whether the end product of the scientist's research is always beneficial to mankind:

> Specialism among scientists has also led some to an increasing inability to see specialized knowledge in its total relation to the truth-seeking effort. Whitehead rightly points out that "as the subject-matter of a science expands, its relevance to the universe contracts." And as the specialist refines his methods and limits his range of study, there is the danger that he will be less interested in its relevance and less concerned to see the bearing of his findings upon the rest of the body politic.[17]

Hudson recalls the academic consequences:

> In yet another way the invasion of university standards and practices cuts at the taproot of the college—through an overstressing of the principle of specialization or division of labor. . . .The principle of division of labor becomes a bulwark of vested privilege and an actual barrier to the progress of thought and knowledge. . . . A great deal can be done [however], once the fact is recognized that knowledge and wisdom cannot possibly be cut up into mutually exclusive tracts.[18]

Similarly, in their reports on "The Characteristics of the Humanistic-Social Studies in Engineering Education" (J. Eng. Ed., Vol. 36, Jan., 1946, p. 344), R. M. Boarts and J. C. Hodges concede the inadequacy of the conventional training as a preparation for the teaching of the broad type of courses in the humanistic curricula; their criticism is that the "graduate schools turn themselves toward specialization."

[16] Lewis Mumford; "The Condition of Man," New York, Harcourt, Brace & Co., 1944, p. 417.

[17] Ordway Tead, "New Adventures in Democracy," New York, Whittlesy House, McGraw-Hill, 1939, p. 38.

[18] *Op. cit.*, pp. 118–119.

The Specializing Generalist

But what must we oppose to specialization? Here is Osler's nostalgic picture:

It is sad to think that the day of the great polymathic student is at an end; that we may, perhaps, never again see a Scaliger, a Haller, or a Humboldt—men who took the whole field of knowledge for their domain and viewed it as from a pinnacle. And yet a great specializing generalist may arise, who can tell? Some twentieth-century Aristotle may be now tugging at his bottle, as little dreaming as are his parents or his friends of a conquest of the mind, beside which the wonderful victories of the Stagirite will look pale. The value of a really great student to the country is equal to half a dozen grain elevators or a new transcontinental railway. He is a commodity singularly fickle and variable, and not to be grown to order. So far as his advent is concerned there is no telling when or where he may arise.[19]

But at the same time, Osler is careful to disclaim a near facsimile of the type:

The dilettante is abroad in the land, the man who is always venturing on tasks for which he is imperfectly equipped, a habit of mind fostered by the multiplicity of subjects in the curriculum: and while many things are studied, few are studied thoroughly. Men will not take time to get to the heart of a matter. After all, concentration is the price the modern student pays for success. Thoroughness is the most difficult habit to acquire, but it is the pearl of great price, worth all the worry and trouble of the search. The dilettante lives an easy, butterfly life, knowing nothing of the toil and labor with which the treasures of knowledge are dug out of the past, or wrung by patient research in the laboratories. Take, for example, the early history of this country—how easy for the student of the one type to get a smattering, even a fairly full acquaintance with the events of the French and Spanish settlements. Put an original document before him, and it might as well be Arabic. What we need is the other type, the man who knows the records, who, with a broad outlook and drilled in what may be called the embryology of history, has yet a powerful vision for the minutiae of life. It is these kitchen and back-stair men who are to be encouraged, the men who know the subject in hand in all possible relationships. Concentration has its drawbacks. It is possible to become so absorbed in the problem of the "enclitic," or the structure of the flagella of the Trichomonas, or of the toes of the prehistoric horse, that the student loses the sense of proportion in his work, and even wastes a lifetime in researches which are valueless because not in touch with current knowledge. You remember poor Casaubon, in "Middlemarch," whose painful scholarship was lost on this account. The best preventive to this is to get denationalized early. The true student is a citizen of the world, the allegiance of whose soul, at any rate, is too precious to be restricted to a single country. The great minds, the great works transcend all limitations of time, of language, and of race, and the scholar can never feel initiated into the company of the elect until he can approach all of life's problems from the cosmopolitan standpoint. I care not in what subject he may work, the full knowledge cannot be reached without drawing on supplies from lands other than his own—French, English, German, American, Japanese, Russian, Italian—there must be no discrimination by the loyal student who should willingly draw from any and every source with an open mind and a stern resolve to render unto all their dues. I care not on what stream of knowledge he may embark, follow up its course, and the rivulets that feed it flow from many lands. If the work is to be

[19] William Osler, "The Student Life," from *Aequanimitas,* quoted from Franz Montgomery, "Essays in Science and Engineering," Ray Long and Richards R. Smith, New York, 1932, p. 161.

effective he must keep in touch with scholars in other countries.[20]

In short, the extremist position is, as always, the indefensible one. The danger encountered by the would-be generalist is that he will become a mere dilettante; by the specialist, that he will lose contact with his time. Whether the antidote prescribed by Osler for this latter evil is likely to be effective is questionable; surely a group of "denationalized" scientists can become deeply immersed in research of little consequence almost as easily as a group of scientists strongly bound by nationalist ties. One might almost suspect that he has confused dilettantism and provincialism. And Ortega, for one, would surely take exception to Osler's scorn of the student of history in whose hand an original document "might as well be Arabic." Yet, as we shall see presently, the two men agree on what constitutes one of the great needs of our time.

"Narrow Mindedness"

It might be well to point out the inadequacy of the philosophy of the "narrow-minded" scientist-specialist, by calling attention to the inaccuracy of the term used to designate this aberrant phenomenon. In reality, it might be more accurate to reverse the terms "narrow-minded" and "broad-minded" as they are usually applied. For observe: never a scientist has there been who, despite his adult preoccupation with the "mechanics of flars," or the "structure of the flagella of the Trichomonas," has not at one time had a more general view of his subject and an interest in its salient if unobscure aspects. But he has allowed his original wider interest to wane with his increasing preoccupation with his fraction of a fraction of the whole; he has deserted first principles—perhaps because he has a mind on which the obvious soon palls—in favor of more abstruse and esoteric speculation. It is a perpetual challenge to him to lead students into these deeps with him, because he never descends without himself experiencing the titillation of danger and uncertainty. Making his way out again perpetually taxes his pilotage; and he is apt to suppose that his stature in the eyes of others is likely to be directly proportional to the depth and distance to which he—quite often unnecessarily—can plunge himself and his party of students. His interests have become narrow, but only because he was originally so "broad-minded" that he has allowed persons or circumstances to alienate him from his first love.

Now it should be pointed out, before appending our definition of the "broad-minded" type, that such qualities and attitudes as those just portrayed, valuable though they may be in the advancement of scientific knowledge, are antipathetical to the qualities of a good teacher. The good teacher must be one who can confront fundamental facts perpetually and endlessly without becoming bored with them and without adopting a stereotyped routine in presenting them.[21] For to successive gen-

[20] *Ibid.*, pp. 161–162.

[21] "I agree with Whitehead that 'for successful education there must always be a certain freshness in the knowledge dealt with. It must be either new in itself or invested with some novelty of application to the new world of new times. Knowledge does not keep any better than fish. . . . Somehow it must come to the student, as it were, just drawn out of the sea and with the freshness of its immediate importance.'

"This obligation of relevancy and importance cannot be escaped; and it cannot be achieved in a single-minded attention to a narrow specialty. I cannot agree with those

erations of undergraduate students he must present his own overwhelming fascination with his subject; when it has ceased to stimulate him to new awarenesses of old truths and to novel modes of presentation, he has become superannuated. In condemning abstruse research, Barzun takes an unusual position: "the discussion of any classic must be superficial"[22]—not merely because the student is usually reading it for the first time, that is, but because the comments of discussants are either pedantic or superficial in comparison with the text. To Barzun, then, superficiality may have merit.

We are now able easily to formulate our definition of a "broad-minded" person: he is one who never loses sight of basic objectives, never becomes bored with pervasive if elementary truths, never tires of leading some one new to an apprehension of the fundamental and significant aspects of his subject. He it is who is the true teacher—at least upon the undergraduate level. And in his unflagging devotion to his early impression of a subject, in its salient and significant aspects, he is singularly obdurate—we might almost say *narrow minded*.

Dilettantism

We noticed a moment ago that the type most often opposed to the narrow specialist is the dilettante. If anyone desires to become a true specializing generalist, he may have some difficulty in escaping this stigma. As Basilius says, ironically:

> Above all, one must not be more than politely curious about a colleague's work, for to do so is to become a dilettante, to spread one's self too thin.[23]

Instead of taking it as a compliment to the intrinsic value of their subject when a colleague in another department makes an excursion into their fields, too many professors look down their noses upon such an excursion as an infringement of their special license to dispense the gospel in their own parish.

Nevertheless, we must learn to recognize the dilettante when we see him. Osler's picture of him, quoted a moment ago, would prove adequate for our purpose. To that picture, let us append only this: 'Tis the novelty, rather than the freshness, of each new topic that tempts him. He may gather many truths, but such as he does not immediately lose interest in, he files for future reference: never does he examine and re-examine in the light of new associations the ideas he may have acquired in the past. In short, his acquaintance with ideas seldom gets beyond the nodding stage. And almost never does he evince an abiding concern for the pressing problems of his age.

At the risk, then, of fostering dilettantism, it is imperative that some effort be made to fill the greatest need of our own time:

> From all quarters the need presses upon us for a new integration of knowledge, which today lies in pieces scattered all over the world. . . . It has come to be an imminent problem, one which mankind can no longer evade to invent a technique adequate to cope with the accumulation of knowledge now in our possession.[24]
>
> . . . If we fail to cultivate this sort of intellectual effort—effort addressed not to descriptive analysis, after the usual manner of research, but to the task of simplifying, and synthesizing the quintessence of science, without sacrifice of its quality or substantialness—then the future of science itself will be disastrous.

for whom education is in every day and place the same."—Tead, *op. cit.*, p. 50.

[22] *Op. cit.*, p. 153.

[23] *Op. cit.*, p. 428.

[24] Ortega, *op. cit.*, p. 90.

It is imperative that the present dispersion and complication of scientific labors be counterbalanced by the complementary kind of scientific activity, striving toward the concentration and consolidation of knowledge. We need to develop a special type of talent, for the specific function of synthesizing. The destiny of science is at stake.[25]

The need to create sound syntheses and systematizations of knowledge, to be taught in the "Faculty of Culture," will call out a kind of scientific genius which hitherto has existed only as an aberration: the genius for integration. Of necessity this means specialization, as all creative effort inevitably does; but this time the man will be specializing in the construction of the whole. . . . Men endowed with this genius come nearer being good professors than those who are submerged in their research.[26]

There is a real meaning and increasing validity today in the notion of being "specialists in generalization." The college role hits in upon this need. Not that we want young people to "know less and less about more and more." But college does seek to develop qualities which we know can be applied and used to the advancement of a great miscellany of callings for which brains and character are the basic requisites.[27]

A means for the solution of the technical aspects of this problem has recently been suggested by Dr. Vannevar Bush; but still unsolved is the problem of how we can divert the requisite energies from the fact-gathering to the synthesizing process. If the present trend continues, it is likely that no inventive capacity will ever be adequate to do the winnowing.

True Breadth of Training

It is evident that the doctoral discipline was designed as a corrective to superficiality and dilettantism. To doubt that it accomplishes this objective might seem rash; yet Millett points out that

There is something exceedingly specious about the depth which is the alleged goal of traditional graduate training. At best, most graduate students are not likely to devote more than a year or so to the special field in which their dissertations are produced. The rest of such students' time is engaged in getting a more or less superficial knowledge of the whole subject matter of their general field. The "depth" achieved is chronological rather than intellectual. It seems unquestionable that a graduate student trained in various approaches to all the aspects of the Renaissance would have a deeper knowledge than a student who devotes half his time to getting up a field that may cover centuries, a quarter of his time to orienting himself in his "period" and the remainder of his time to writing a dissertation on a hole-in-a-corner subject in his period.[28]

Millett describes the graduate school which he believes would provide a much more satisfactory type of training:

What one would like to see is the establishment by some energetic small academic college of a humanistic graduate school planned and operated on almost completely novel lines. Such a graduate school could start without the handicaps of the traditional historical methods and could devote itself to training students, not to become specialists in English, philosophy, music, or the fine arts, but to become oriented in all the aspects of a particular culture and skilled in interpreting the relationships between those aspects. Fundamental to such a school or institute would be training, not merely in the scientific-historical method of studying the humanities, but equally in the systematic, analytical, and critical methods of studying those subjects. Tradi-

[25] *Ibid.*, pp. 88, 89.
[26] *Ibid.*, p. 91.
[27] Tead, *op. cit.*, p. 31.
[28] *Op. cit.*, p. 145.

tionalists will at once object that such a training would result in breadth, perhaps, but not in depth, but there is no reason why this should be the result. Indeed, it may well be argued that a graduate student who devoted three years to studying the Renaissance or the Victorian era would have not only a depth but a breadth unlike that attained except by a very few absolutely first-rate scholars and critics.[29]

Surely such training would enable teachers to establish the integrated type of program for which Wickenden pleads:

> We (engineers) do not justify our position if we make our humanistic-social program a collection of oddments and remainders, a bit of this and a smattering of that, demanding casual effort and superficial achievement. . . . We do not justify it if we let teachers of humanities regard us as Philistines and excuse their efforts in our behalf as a missionary enterprise. We do not justify it if we neglect scholarly effort to interpret science and technology in their human, social, and cultural values. To be very blunt about it, it is now time to put up or shut up—to give the humanities, and the social studies the time, the leadership, the manpower, the content and the financial support that will put them on a level in prestige and excellence with our scientific disciplines.[30]

Integration

A few reassurances need to be voiced, seemingly, for those who detect something sinister in the term *integration:*

> We have felt that perhaps integration meant absorption, and that our task would be simply that we should correct the reports and essays of the engineering departments. That, I think, is certainly not the intention of the framers of the report, and I continue the plea that the men in the engineering departments give the ideals of integration a little different meaning from that.[31]

. It is understandable, in the light of past experience in engineering schools, that the teachers in departments of language or English are under no misapprehension as to who will be the swallower and who the swallowee in any case of deglutition. Elsewhere, Thompson has been somewhat bolder in suggesting where the responsibility lies for correcting technical reports:

> . . . Inasmuch as the English Language is the medium through which mechanics, metallurgy, physics, chemistry, etc., are taught to students, the insistence by the teachers of these subjects on correctness of vocabulary, grammar, and form (spelling?) will do a great deal to make engineers aware of the constant importance of good writing.[32]

And other writers, far from being perturbed about being swallowed alive, are ready to carry the war to the enemy's country:

> Have we not been asking the staffs who teach these subjects (English and the humanities) to assume responsibilities for which the members of the technical staffs should be held accountable? Is it not the duty of *each* staff member to see to it that papers and reports submitted to him are in good form; that the spelling is correct and that the English is reasonably correct? . . . Surely any competent staff member should be able to assume this responsibility. And, on the other hand, should we expect, or even wish, the staffs of the Humanistic and social science branches to cramp their missions, by forcing them to try to bolster up techniques

[29] *Ibid.*, pp. 144–145.
[30] *Op. cit.*, p. 46.
[31] Karl O. Thompson, "Engineering Education after the War," J. Eng. Ed., Vol. 35 (Sept., 1944), p. 57.
[32] Karl O. Thompson, "English and the Humanistic-Social Division," J. Eng. Ed., Vol. 36 (Nov., 1945), p. 169.

for which ground work was laid in high school and which should be developed by the technical staff? Are we giving the staffs of the Humanistic and social science groups an opportunity to do what they should be doing, namely, expanding appreciation of the best in literature, art, music, philosophy, history, psychology, economics, political science, etc., etc.?[33]

Most of the teachers of English who have been long upon the staff in an engineering college are aware, however, that the millennium has not arrived. They know that to shift the responsibility to those who do not want it, have so far eschewed it, or are unable to assume it will not solve the problem. And in truth it may be seriously doubted whether, in the ideal college, the teaching of the fundamentals of grammar *should* be left to the faculty as a whole.

For one thing, as any experienced paper grader knows, it is not feasible to check the technical accuracy, grammar, diction, spelling, punctuation, organization, and content of a paper in one reading. Hence if someone has to check on these details, let it be someone hired—and paid—to do *this* job, and not an often more remunerative (if not prepossessing) task.

More important, the proposal to entrust instruction in English to the technical staff (ignoring their willingness or ability to shoulder such a responsibility) is only a reminder that far too often it is blandly assumed that anyone can teach English. Faulty though this assumption is, it is less to be decried than its corollary—that anyone in the English department can teach the humanities. Here is where we are likely to do irreparable harm to the whole humanistic program.

Undoubtedly there are many English teachers who can and will creditably perform the task of teaching the humanities. Unquestionably there are many in the technical branches who will do—nay, who have long done it quite as well; for not all philosophy is taught in a course by that title; and if the psychologists have a monopoly on their subject, then

I never writ, and no man ever loved.

Says Tead,

> That generalizing and synthesizing process which is one's philosophy will ideally be encouraged not alone by those teaching a subject called "philosophy," but by those maturer teachers (admittedly rare under present conditions of teacher training) who can become truly philosophical out of their own special subject field.[34]

The Liaison Professor

The fact is that there is need for as many differently trained teachers as there are individual staff members in most English departments. For those with a penchant for science, there is an infinite variety of courses in the engineering curriculum, study in any of which should repay the student-teacher both in increased interest in the content of the papers turned in by his students and in increased proficiency in detecting errors in fact. The chances are that too many English teachers balk at grading technical reports because they feel incompetent to deal with technical problems. Then let them remedy their deficiencies in the only way possible! Close contact both with professors of the other departments and with the students should qualify the teacher un-

[33] F. W. Roys, "Humanistic and Social Science Subjects in Relation to the Engineering Curriculum," J. Eng. Ed., Vol. 36 (Nov., 1945), p. 205.

[34] *Op. cit.*, p. 33.

dertaking a program of undergraduate engineering studies to adapt the work of his department to the needs of the students he is reputedly serving and to the objectives of other departments, particularly in the writing of reports. In fact, a title, such as that of Liaison Professor, might well be awarded one who chose to follow this line of continuing education in preference to work upon a doctoral dissertation in his own field; and such a position might be created in every department, to minimize the extreme departmentalization and specialization which typify our present educational system.

. . . I think the humanistic professors will have to come half way to meet the engineering students to get their interest. A great many humanistic professors have never studied engineering, and have very little knowledge of mathematics or physics. They do not know enough about the hard, cold logic of things to talk the same language with the engineering students. If they could educate themselves by perhaps taking some of the engineering courses so that they could talk the same language as the students they could lead the student along. If the professor of English can get the enthusiastic support of the students then he can lead them over into the more cultural part of the subjects—which is necessary to give clarity, conciseness and elegance to anything which is written. I think that by leading in that way they can accomplish what they want; but they can't stand on the other side of the river and call to the student to come across and hope that he will come with enthusiasm.[35]

First, let it be said that teachers of English must and can adapt themselves better to the engineering atmosphere and try to understand more adequately the professional standards and needs of the graduates. This will not always be easy and will call for closer cooperation throughout the whole faculty than has often prevailed. The teacher of English need not cease to be a specialist in his field, but he must be a part of the engineering educative process.[36]

An Experiment in Method

If a member of the department of English were to devote himself to such training, it should enable him to perform an experiment in education which would be watched with a great deal of interest. For there are innumerable individuals in this world whose knowledge of formal grammar and the principles of rhetoric is rudimentary in the extreme, yet whose proficiency in the use of language is indisputable. They may never have learned formal grammar, or they may have forgotten most of what they once knew. In any case, they have somehow acquired a proficiency which may be the envy of many of their fellows. Every teacher of English has known such people and has wondered whether their ability has not called into question the methods and content of instruction in vogue in most classes in English.

Now, if, through careful testing, an average group in a class of entering freshmen were segregated for purposes of this experiment, their schedule might be arranged so as to omit all study of English as a tool subject. Instead of studying formal grammar three isolated hours or so a week, and forgetting within a year or less most of what they have learned, they could be expected to be on the *qui vivre* in all the papers they write during their college years, most of which will be read and marked

[35] A. R. Stevenson, "Engineering Education after the War," J. Eng. Ed., Vol. 35 (Sept., 1944), p. 57.

[36] Karl O. Thompson, "English and the Humanistic-Social Division," J. Eng. Ed., Vol. 36 (Nov., 1945), p. 164.

for correction by a Liaison Professor, who might even be in some of their classes with them, and thus subject their powers of oral exposition to quite as searching scrutiny.

At the end of four years, adequate tests could surely be devised to ascertain the relative achievement of the two groups—those who studied grammar as an isolated subject and on their own initiative, applied it in their other courses; and those who sacrificed a study of formal grammar for a continuous attention to the accuracy and effectiveness of all their expression. Undoubtedly a blend of the two methods would turn out to be the most satisfactory in the long run; but not even a compromise could be attempted, if their were no one to initiate the project and give to the accuracy and effectiveness of students' writing in technical courses the attention these matters really deserve.

In the numerous engineering colleges at present vacillating between the four and five-year curricula (chiefly as a result of the report of the Hammond committee or a long-standing recognition of the necessity for such a move as the committee proposes), the services of the Liaison Professor might be of great value; for, through his recommendations, unnecessary duplication and overlapping of courses and superfluous subject matter might be eliminated. In short, retention of the four-year plan might be feasible only through recommendations of a corps of men sufficiently trained outside their own fields to be able to judge dispassionately the offerings of their own departments and to correlate their courses with the others on the students' schedules.

It is withal a strange thing that after a student finishes his undergraduate work, he is virtually condemned to the isolation symptomatic of the graduate school. On virtually every campus there seems to be a wall of fire surrounding each of the departments, and it is apparently given to only the undergraduate students to know the mysteries that enable one to pass from one encircled citadel to another. It is unusual indeed for a teacher, nostalgic for his student days, to try to pierce the barriers; but if his specialization has not prevented him from succeeding, he should be able to help the students, many of whom never learn to grope from one subject to the other without forgetting much of their experience of the hour, the day, or the year before.[37]

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[37] I think that the nomenclature, the methods of teaching, and so forth, have spread useless division of the same subject.

When I was in school one of the great pet controversies was whether the student in the physics department knew how to weigh anything on a chemical balance, and vice versa. In other words, we can never see any difference between chemistry and physics or between biology and physics. They are all material and energy relationships in which molecules, atoms and so forth are involved, and calling them different sciences and adding a lot of Latin and Greek names doesn't help the situation.—C. F. Kettering, in "The Future of Industrial Research," Standard Oil Development Company, 1945, p. 67.

At the level of the efforts of the entire teaching staff, the purpose of the college is best served if the compartmentalizing of knowledge and the departmentalizing of subjects are minimized far more than is now typically the case. Tead, *op. cit.*, p. 28.

We must bring about a better wedding between physical research and the so-called chemical sciences and chemical engineering which underlie the process industries of today.

The university men with whom I have discussed this problem during the last few years have all acknowledged the problem, but none of them has suggested any solution. Frank A. Howard, in "The Future of Industrial Research," p. 67.

A Second Type of Training

Such work as that which is to be undertaken by the Liaison Professor (but which will not help him to earn the degree of Ph.D.), is not the only type of activity upon which he might embark. If an effective system of integrated undergraduate courses in the humanities is to be worked out, teachers will be required who have had courses (necessarily undergraduate for the most part) in a number of departments. As Basilius has testified, it is no easy task for humanists of several sorts to get together, evolve a common language, determine similarities in objectives, and produce a common basis for evaluation of disparate subject matter. Yet if the teachers cannot do this, how can the students be expected to perceive anything but a hodge-podge—"a collection of oddments and remainders"—in the work presented to them? Of such integration as is here requisite, specialization is surely the enemy. It is only sensible, then, to encourage those entrusted with teaching in such a program to enroll in undergraduate courses in as many of the humanistic disciplines as they have time for. Strong intellectual curiosity will inevitably lead to the development of special interests; as long as these do not preclude simultaneous breadth of ken, they may be looked upon as an antidote to possible dilettantism.

Hudson shows effectively the role to which research should be relegated:

> Even the lower stages of these subjects (language, mathematics, and science) have high potential value as contributing to the student's understanding of his world. Even elementary knowledge, so far as it is knowledge, is worth being dwelt with: its implications can be followed, its method inculcated, its place in the scheme of things made clear and important.[38]

> My point is that to set up scholarship as a requisite for the college teacher helps very little in determining his character or in insuring his excellence. I agree that he should have experienced the pains and pleasures of scholarship, should have got the feel of first-hand investigation, should have learned an appreciation of knowledge "the hard way"—that is, by finding through experience how difficult is the discovery or validation of a piece of it. But I would add to all this an additional requirement; namely that he should be a student, and should maintain the attitude of a student, not only with respect to his own subject but also with respect to other subjects and to the book of life and experience itself.[39]

> We know that our students fail, somehow, to learn to read with pleasure and intelligence. Possibly the reason is that their teachers have stopped reading for pleasure, too, and read with intelligence only what falls within the fields of their specialties. . . . The inadequacy of the scholar, pure and simple, when considered either as the guide or as the end-product of education, is that he pursues knowledge rather than wisdom.[40]

One of the serious results of the primacy of the scientific approach to humanistic studies has been its influence in breaking up the subject matter of the field into smaller and smaller segments, with the resulting departmentalization and compartmentalization of knowledge. Millett, *op. cit.*, p. 18.

It is true that the whole field of knowledge is so vast that it is necessary for the purposes of study to divide it into sections, examining each at a time. The trouble is that, in the present status of rigid departmental organization, the sections are never put together again and the students are never given definite help to organize the parts into intelligible wholes. T. H-E Chen, "Developing Patterns of the College Curriculum in the United States," U. of Southern Cal. Press, 1940, quoted in Millett, *op. cit.*, p. 154.

[38] Hudson, *op. cit.*, p. 111.
[39] *Ibid.*, p. 114.
[40] *Ibid.*, pp. 115–116.

Probably the truest test of the value of research lies in whether its results can be presented to undergraduates zealously and without self-consciousness.

The Third Proposal

So far, then, we have outlined two types of training of particular value for the teacher of the humanities in engineering colleges; and neither, it must be noted, would ordinarily lead to the degree of Ph.D. There is still one type of research which has been particularly recommended by Wickenden:

> The realm of science and technology is probably the richest unworked ore body of human and cultural values in the world today. Here is material teeming with historical, biographical, dramatic, and artistic interest. Why should it wait in vain for interpretive genius, while teachers of humanities in engineering schools lament that their lot is barren and routine? . . .
>
> I am inclined to think we should seek our instructors in humanistic areas at the pre-doctoral level, give them a thorough tryout, then provide selected men with fellowship grants for the final stage of graduate work, and insist upon their choosing dissertations that have a significant bearing upon science and technology as related to human culture, history, and welfare.[41]

Now to this proposal of Wickenden's, exception must be taken on two counts. In the first place, as has already been mentioned, frequently graduate work is synonymous with specialization and hence, far too often, is the foe of the breadth of interest so important for the kind of humanistic teaching demanded in the engineering curriculum.

In the second place, the value of the particular study which Wickenden commends for the dissertation must be questioned. A great deal of work has already been done in recording the history of science; the raw material for many dissertations on "science and technology as related to human culture, history, and welfare" is already available. What is not so certain, however, is that there is any except a fortuitous connection between science and human welfare (despite the arguments of the social scientists who, it will be remembered, insist that the concept of value underlies all scientific research).

If this sounds paradoxical, in view of the tremendous contributions science has made to mankind within the last century, consider that in the last analysis, scientists are amoral. They may be saddened by the reflection that their inventions may be misused for evil purposes, but they do not withhold their developments on that account.[42] Does any one suppose that the scientists who were working on the atomic bomb project for the Nazis will desist, now that they are laboring under the British aegis? Has the possibility of miscalculation or unforeseen consequences in atomic research—which, as has been before remarked, may make a funeral pyre of earth—seriously delayed developments in this field? Even a great physician and researcher like Banting, whose discovery of insulin spelled life for literally millions, seems not to have protested too much at being pressed into service in the department of biological warfare, in which capacity he might have been in a position to loose a plague of frightening aspect upon a civilian populace.

Now all of this is recounted, not to charge the scientists with the misuses of the products of their ingenuity, but to emphasize another point: the scientist's relation to his work is impersonal

[41] Wickenden, *op. cit.*, pp. 47–48.

[42] A notable exception was Archimedes.

and, except as he is the accidental possessor of the prowess which results in discovery, coincidental. In short, if we are not to judge scientists responsible for the misapplication of their discoveries, we must virtually ignore their connection with their discoveries. To put it another way, we may say that a thorough knowledge of the history of science may be justified merely because first, the doctrine of knowledge for its own sake may have some *slight* validity; second, such knowledge recalled in isolated packets as illustrative material when the occasion is apt—the sort of use to which Barzun apparently puts it [43] may have a stimulating and provocative effect upon the young, who require inspiration and direction; and third, such knowledge is "cultural"—as most types of antiquarianism are generally conceded to be.

These are harsh words. But the history of science and the history of the other activities of the race are not on the same level. De Quincy showed irrefutably in "Literature of Knowledge and Literature of Power" that factual literature—in the former category—can be entirely dissociated from its author. Literature of power is completely changed when it is paraphrased; literature of knowledge can be restated, and it loses nothing, or only that little which it possesses by being simultaneously in the other category. Similarly, anyone can comprehend and adopt for his own a scientific concept, which has existence outside of the words of its discoverer. And a simple invention can be so perfected by succesive generations that the original concept—the first model—may be the smallest part of it. There is even something specious in tracing back invention to some individual: was the electric motor derived ultimately from the work of Faraday, or from the discovery of the attractive properties of the lodestone? Was not the polishing of gems to bring out their refractive power a necessary first step in the development of the spectroscope?

Just as it is a mistake to teach students science by having them read all the records of the fumbling that has occurred up to the present time, so it is a mistake to emphasize the history of science as if the scientists and inventors of past ages had the same relationship to their inventions and discoveries as an artist has to his painting, a poet to his lyric.[44] The high school boy today can know more about electricity from a poorly written textbook composed by a third-rate scientist than was know by a savant a century ago.[45]

[43] Barzun, *op. cit.*, p. 99.

[44] If it seems the act of an ingrate to take what is handed on to us without due regard for the donor, bear in mind that as the greatest tribute we can give to a deceased author is heartfelt appreciation of what he wrote, so the only adequate tribute to an inventor or scientist long dead is use of the device he developed or the principles he enunciated; and if the device or principle becomes obsolete, so then is virtually all reason for exalting his name above the legions in limbo. Moreover, "the real scientist, considered as a person, has been with notorious frequency a visionary freak, when he has not been absolutely demented. The real marvel, the precious thing, is what this very limited person succeeds in isolating: the pearl, not the oyster that secreted it."—Ortega, *op. cit.*, p. 76.

[45] There is a fourth commonly alleged justification of the study of the history of science: the grander conceptions of the function of history now current, emphasize the importance of dealing with the entire milieu in the re-creation of any historical era. (As Ortega puts it, the purpose of history is to enable us to form a picture of the mind slant—the world concept—of an individual who lived during a particular period in history.) If one is content, then, to be classified as a

And surely this must be evident to the student of the history of science. While he is laboring on his fruitless quest, he must be longing for the time to read the latest findings on atomic research; to browse through a treatise on cosmic rays that will furnish him with a hint of the connection between that fascinating topic and the development of atomic power; to reread his biology and the theory of mutations, the better to understand the possible effect of cosmic radiation upon the evolution of life upon the earth. And this is as it should be—unless, indeed, the student's interest is fundamentally an antiquarian one: in which case, we hope, he will not (at least in any great numbers) clutter up our engineering faculty.

And so we come back to our thesis. For the development of teachers of English and the humanities there are two [46] requisites: first, conceivably a revitalized and broadened doctorate, or, more likely (in view of the present status of the doctoral training), a program of largely *undergraduate* study (in engineering, to give the teacher an appreciation of the peculiar problems of the engineer, and in a multitude of the humane disciplines, to enable him to lead the engineer beyond the limitations of his own circumscribed horizons); and second, sufficient abiding interests to prompt at least a token measure of research in whatever seems most fascinating, and could be communicated to undergraduates without preciosity. Only so much research would be warranted, however, as would not conflict with the necessity for tying together as much knowledge as present discoveries will point the way toward unifying.

historian and to form his concept of reality and his insight into the nature of man and his universe through the laborious process of historical research, let him; but for those who cannot rest content, cut off from the latest achievements in science that will color the lives of the coming generation, let them adopt the more direct approach. For every Agassiz or Einstein who surveys ultimate reality from his pinnacle of specialized knowledge, there are a thousand lesser mentalities whom such specialization cuts off altogether from their own times. Let us not be misled: from his upthrust promontory of mathematics, Einstein was able to point in one direction to what the astronomer would some day achieve; in another, to the secrets which the physicist and chemist would some day wrest from nature. But not John Middleground, B.A., M.A., instructor in English and the humanities at Sacristan College of Engineering. For him, specialized knowledge is converted into a pair of inverted binoculars, through which he peers at reality as if toward the bottom of a well; small wonder if he finds it hard to retain his balance while looking at matters so distantly proximate!

[46] That additional methods of preparation exist cannot be doubted. Intensive reading; participation in community life; participation in courses in adult education; exchange professorships—such means as these, although outside the scope of this paper, should certainly be included in the program for professional development.

The Engineer Family in the British Commonwealth*

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Address delivered at the Sixtieth Annual Banquet of The Engineering Institute of Canada held in the Mount Royal Hotel, Montreal, Que., on Friday, February 8, 1946

(*As recorded verbatim by the stenotypist*)

Mr. President, Ladies and Gentlemen:

I appreciate very highly the honour which you have done me this evening in inviting me to come here and be your guest speaker. I think of the remarks which were made by a speaker at the luncheon today who said how very pleased he was to come back to Montreal, to Canada, after an absence during which time he had retained many happy memories of former visits. I am not fortunate enough to have had former visits to this delightful country of yours but I am quite sure, after a space of only 36 hours, that I shall come back again at the earliest opportunity.

It so happens that the invitation from your Institute to The Institution of Electrical Engineers came at a very appropriate time. So far as I am personally concerned it arrived at a happy moment when, as president of that Institution in the first peace-time year, I was having opportunities which had not been available to any president for the past six years. Your invitation came, therefore, at a time when no president could possibly decline even if he had wished to do so.

It was also a happy coincidence that the other two chief Institutions of Engineers, the Institution of Civil Engineers and the Institution of Mechanical Engineers, were both happy to allow me to represent them as well as my own Institution, at this most important gathering.

It also happened, Mr. President, that at the time of receiving your invitation my Institution, along with the other two bodies, were considering a subject which is of very great interest to your own Institute. We have had in mind for some time past the possibility of taking action to secure a better co-ordination throughout the Commonwealth, of engineering interests on all three sides, civil, mechanical, and electrical, and during the past few months those discussions have gone quite a long way, so that when your invitation came we said at once: "Here is an excellent opportunity to advance those relationships with the other parts of the British Commonwealth, the Dominions overseas, for which we are all seeking."

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Commonwealth Conference

There would be many important questions to be settled in discussing this matter and I have very great pleasure today, therefore, in telling those of you who are not already aware, that during the coming summer we are arranging to hold in London a conference of the Commonwealth at which we are hoping to have delegates from every one of the Dominions. We have issued invitations and were very pleased indeed when the first acceptance came very quickly from The Engineering Institute of Canada. Not only did it come quickly but the enthusiastic terms with which you accepted our invitation gave us very great pleasure and inspired us for the work of the conference.

It is too early for me to attempt to outline the objectives which we hope to achieve in the summer when we all get together but we are hoping, Sir, that your representatives, while they are in London, will be the guests of our Institution. In this connection the three Institutions are operating together and, although no details can be proposed at this stage until we have more discussions, we can, I think, secure quick agreement on our general policy. Obviously the object of that conference will be to strengthen in every possible way the bonds of cooperation between the Dominions and the Mother Country in all matters which affect engineering. We shall hope to treat every matter in such a way that the individual societies in the different national groups will be able to fall in with a common policy which will bring interest to those separate groups and at the same time will be in the common interests. Naturally, we shall avoid taking any steps which would interfere with the government of the individual members.

Professional Organization in Great Britain

It may be that you would like to know a least something of the set-up which we have in our country carrying out the work which you are doing so admirably in your Institute here. Instead of having one body such as the E.I.C. which covers all branches of engineering, we have three separate institutions. They were formed at different times and have complete autonomy. They have also their separate buildings in which meetings and administration are carried on. The Institution of Civil Engineers was formed in 1818 and today has a membership of 15,000. The Institution of Mechanical Engineers was formed in 1847 and today has about 20,000 members. The Institution of Electrical Engineers is the baby of the three as it was formed in 1871 and now has a membership of 28,000.

Sometimes we have regrets that we are separate bodies. For many reasons it would be an advantage if we had joint administration and joint policy but in engineering bodies there seem to be schisms from time to time, breakings apart and reconnections and if we take a biological example we may say that is only a sign of really good health.

I am always reminded, when I refer to a biological example, of a speech I made when I was a very young man. In fact I think it was the very first time I spoke at a public gathering. This was at Liverpool University in the days when I, like many other young men, tried to prove the fallacies of socialism. I remember to this very day a question which I put to the audi-

ence: "What does the whole science of biology teach us?" I do not know now what answer I expected but I do remember that the theatre went up in serried ranks to the ceiling and that there was a lady in the back row, a very bright, young undergraduate, who immediately gave me the answer. It finished me for the day.

But although we have these three separate institutions and although we have complete autonomy, I am glad to be able to tell you that we are very happy in our relations with one another. In order to bring our common policies together as much as possible, we hold informal meetings of the three presidents. They meet under entirely informal conditions and in that way try to apply common sense to current problems and we are able to bring our common viewpoint to bear in such a way that perhaps we achieve much of what you get through your one body controlling all the different interests.

We also recognize, although we think we are the three main Institutions and cover the three main branches of engineering, certain other bodies which are quite strong, healthy, active, representative of engineers such as the Marine Engineers, the Aeronautical Society, the Institute of Naval Architects and the Municipal and County Engineers. It is interesting to note in connection with tendencies of administration how the approach of these Institutions is changing under modern conditions. I do not know whether you have noticed it with your body here but we have noticed quite definite changes in trend. We are being sought out by members of the engineering profession who have already established themselves. In the past, the distant past, the Institutions were approached by young men wishing to make a position in life but today more and more we are finding that those who in their youth did not take an interest in the Institution are now coming in and we feel that this is an example of what is being referred to at your conference here this week, the feeling that is getting abroad that the object of the engineering society or institute is to render service to the community rather than service to the individual member.

Service to the Community

These men who are now coming in to make application for admission are not coming in entirely for the sake of what they would get out of the Institution but because of a general wave of feeling throughout Britain that national bodies of this kind are worthwhile and should be supported. I hope that we shall see an increase in that attitude toward our national engineering bodies because I feel it is good for the profession.

That question of service to the community about which we are hearing so much, and quite rightly too, leads me to the general question that I have adopted for the title of this talk, "The Engineer Family in the British Commonwealth." There could be no closer tie between the different members of the Commonwealth than a tie such as we get in our common interests as engineers. Our three British Institutions each possess a charter and in the charter the objects of the institution are clearly laid down. In all three they are the same. The object of the institution is the advancement of science and its application for the good of humanity. If we live up to that charter we clearly are going to promote science and in applying this science we are going to benefit our fellow men. What better common ground could there be for co-

operation throughout the Commonwealth than such a basis?

Engineer's Contribution to Allied Cause

The war has given us during the past six years many examples of the way in which the engineer is more and more being looked upon as the one profession, if I may say so, in which service to the community is the "be all and end all."

This afternoon I had the privilege of speaking at one of the professional meetings and outlined some of the activities of the engineer at home during the last six years. There is no time this evening to refer to more than a few of those activities but I think you probably would like to have me make a reference to them.

I want to tell you that it is my firm belief and the firm belief of many engineers in my country that the British engineer contributed very largely to the successful outcome of the Allied cause.

Civil Engineering

There were many things done in London which will never get into the newspapers because by now they are stale news from the point of view of the ordinary man in the street. I do feel, and this is one of my reasons for being in this country, that these things should be said over and over again. How many people appreciate today the extent to which the civil engineers devoted their professional ability to securing the safety of the millions of people who lived in London through the bombardment? Very few indeed. We had three underground citadels in London and, without going into the millions of tons of concrete and the millions of pounds they cost, I could give you an idea of one of them when I tell you it would house thousands of people who were concerned with the conduct of the war for at least three weeks without any outside communication at all. It had every possible requirement and was built during the war without the knowledge of the people in the neighbourhood. Many people who lived over that citadel, built 50 feet below the ground, never knew it was being constructed.

Shelters for the population were distributed to a very great extent on a basis of—"Here is the shelter. Put it up for yourself." We had what is known as the Anderson shelter and 2½ millions of these, taking many hundreds of tons of steel in their construction, were handed out to people who erected them, digging small holes in their backyards and then having erected these shelters lived there the worst nights of the blitz as they came along. The accommodation provided in that way was, of course, not of a permanent nature but it resulted in a considerable saving of life because experience showed that people were not killed by a direct hit of a bomb but by houses falling on them. If, during an air-raid, they would go into their gardens and get under their shelters a little below the ground they were protected from the glass and, in that way, thousands of lives were saved.

Another contribution of the civil engineers which is known, but again not appreciated, is the extent to which they employed hundreds of thousands of workmen constructing airfields in Britain. There again one could mention millions of tons of soil that had to be moved but, to sum up the whole thing, the total area of runway that was provided for the British Commonwealth and American Air Transport flying

from Britain to the Continent would represent a roadway in the neighbourhood of thirty feet wide and ten thousand miles long. I think that gives you a rough picture of the magnitude of that one task.

Mechanical Engineering

The mechanical engineers' contribution was a most spectacular one, in aircraft design and development, and particularly in jet propulsion. The latter work was done principally through the efforts of one man and has been referred to on many occasions. I mean, of course, Air Commodore Whittle, who from about 1930 to 1941 fought against technical difficulties and administrative apathy. However in a comparatively short time he produced the gas turbine. Practical trials began about 1935 and, in 1941, the first flight tests were made, and when the flying bombs were launched against us in 1944 the jet propelled aircraft provided a valuable weapon of defence for our island.

One of the things for which mechanical engineers deserve great credit was the development of the tank. We had an old fashioned tank in 1939 with which our soldiers had to go into war against the most up to date tanks. Its main armament was a .303 inch machine gun and it had an engine of 80 horsepower. Three years later we sent over our Churchill, 500–600 h.p. In four years our mechanical engineering designers caught up to the previous eight years' work on the German engineers. They did in four years what the German engineers had done in 12 years and beat them at their own game.

Electrical Engineering

A very great deal could be said, again, about radar and the contributions of the electrical engineer through this most spectacular device. Radar has now become a very popular study and some of the younger students know considerably more about the subject than I do. In 1939 we had started using radar, a few months before the war broke out, in providing coastal chain stations which ultimately were to become such a valuable defence against German planes flying across England. An experimental station had been built at Orfordness for floodlighting an area out to sea with radio waves and receiving reflections from ships and aircrafts some distance from the coast. The results were so successful that by the time the war broke out we were able to establish a complete set of stations at 50-mile intervals around our shores from South Wales and the South and East Coasts to Scotland.

However, the first station installed did not take into account the low-flying aircraft and, in order to stop these raiders, a group of shorter-wave transmitters with rotating aerials mounted on tall towers and synchronized were added to the floodlight stations. These were known as Chain Home Low Stations and were very accurate in catching those low flying planes coming in. This equipment gave our limited number of fighter machines and pilots information on position, speed and altitude of the raiders which enabled such spectacular results as when 185 enemy aircraft were destroyed in one day by pilots or our machines, inferior in numbers but so superior in courage.

I am old enough as an engineer to be able to look on new developments with a feeling that wonders never cease and that the days of miracles are not passed. The way in which ground-controlled interception and air interception could establish the position of

a raiding machine, could send a signal to a two-man fighter plane in which we had a radar device, direct them through the thickest fogs and darkest clouds to fight until the enemy ceased to exist will ever be to me a source of wonder. I think on many occasions the German raider never really knew what had happened to him for it was all over so quickly.

When we consider that what these planes were guided by was not a single device or by actually seeing the ground below through the fog and mist but by using what is known as the H-2-S system, we must be filled with admiration for those men who worked so assiduously on development of designs and by their dauntless courage helped to overthrow the forces of barbarism. Those are the days in which the final results of the war were really settled. Except for the devotion of those men the war might have ended very differently.

The anti-aircraft control is a device with which anyone living in England in 1940–1941 was very familiar but it was a curious thing about these anti-aircraft guns, nobody ever talked about them. I had a daughter-in-law about 21. She used to go to some business or other about which I did not ask and about which she said nothing although I did know it was some sort of war job. Later I learned that her work was in one of the towers and connected with directing gunfire on aeroplanes. That is just typical of what was going on all the time.

Much of our work was more spectacular, particularly with the advent of the flying bomb, without interference of any human hand whatever. One device had a projecting mirror and was known as Cupid and is a small radar set operating in the centimetric band and designed to search for and follow automatically V-1 flying bombs. It is mounted directly above a close-range predictor. This apparatus made possible too good results against the flying bomb. It was a great occasion when we knew we could successfully combat that weapon. We remember that occasion very well because of the fact that 80 per cent of the docks were afire at that time. I remember it for a different reason also. I have a picture of the chairman of my company, a portly gentleman, and his secretary, a very portly lady, diving under the table at each new explosion and emerging very cautiously, about once every five minutes. It all seems funny now but it was not funny at that time.

Pluto

One morning a representative of the Army came to us and said, "We want you to devise some means of getting a million gallons of petrol arcoss the Channel daily. Not much of a job. Just get on with it." So one of the British oil companies and the cable-makers got together and very quickly we were able to devise a lead-alloy pipe about 3" in diameter, with four steel tapes and longitudinally steelwire armoured, which could withstand an internal test pressure of 4,000 lbs. per square inch. Between April 1942 and October 1944 a total of 570 nautical miles of this armoured pipe was made by five British firms and 140 miles to the same design brought over from the United States. A plain 3" steel pipe welded into continuous lengths each of 70 miles and paid out from floating drums was also used for part of the work. That pipe was laid one very summery afternoon and it was a big installation. This operation was known as Pluto. The results that the Army wanted were achieved.

Magnetic Mines

A great deal could be said, again, on the way the engineers have handled the problem of defeating the magnetic mines. Trouble arose in the early months of the war and many ships were lost during September, October and November 1939, but a party of engineers from *H. M. S. Vernon,* whose names should go down in history but I do not think anyone knows their names and they are not men who wanted any particular credit, approached this problem of mines and found out exactly the details of the magnetic properties of the mine. The antidote soon followed. Ships were protected in two ways, first by magnetic treatment at intervals by passing heavy currents for short periods through temporary coils rigged around the ship, or, secondly, by the installation of permanent "degaussing" coils fed from the ship's supply. Ten thousand warships and merchant vessels were fitted in that manner.

This kept the cablemakers pretty busy. They produced large quantities of single-core cable which was made up into sausage coils with hessian strips and laid in the scuppers around the vessel. Previously the object was to blow up the mine rather than to protect the ship against a live mine and that was achieved but the double-L sweep method had been evolved and this system was destined to dispose during the next few years of many thousand magnetic mines.

The big problem with the cable was that all cables sink into water. Cables are not made like "Ivory soap, it floats," and so we had to get some means whereby the cable would stay on the surface. Various designs were achieved, one of which has brought me a good deal of discredit because so many of my friends have said "we ought to be able to get at least an afternoon's tennis" but the tennis balls were all being used to hold up the cable.

Engineers under the Blitz

I do not want to go on detailing these technical things but I would like to pay tribute, before I stop, to those men of the engineering profession, civil, mechanical and electrical, who maintained such splendid service in London during the blitz. Time and time again roads would be blocked, sewers would be burst, electric power was shut off and yet, immediately a raid was over, they would effect restoration of the various services as quickly as possible. I am tempted on this occasion to reminisce about one little incident which I think I shall always remember. It does not really apply so much to the engineer, though.

I was passing a fire station one day during an air raid and the firemen, as usual, were ready for anything to happen. A flying bomb was coming over and I heard one of the chaps say to another standing at the door "Start up, George," and they started running, chasing that bomb down the street, and were on the spot ready to deal with it almost as soon as it landed.

Communications of course gave the engineers a headache. Thousands of long distance trunk circuits were destroyed time and time again by bombs and had to be repaired and it would have done your heart good to see some of those men making repairs with the bombs still flying, carrying on with that most necessary work and being handed cups of tea from mobile canteens. From such things as that one ought to get a very good opinion of human nature.

Recognition of the Engineer

I would like before I sit down to refer to the lessons that one ought to learn from the very unusual experiences we have had during the past six years. There must be something fundamental in this question of engineering and the pride in the job which has kept men on the job, not because they were being compensated but because of a sense of duty, and I can see from your faces that you hold the same view of the essential results of education and training, the position of engineers as administrators and a recognition of engineering status. I would like to take part in your discussions on all these subjects but they are subjects which we could discuss for weeks and months and years before we arrive at the correct conclusions, and it is quite clear that all these things lead to one truth. The social status of engineers is not going to be achieved by engineers individually clamouring for social advancement. It is going to be achieved when the engineer is felt by the community to be worthwhile, and he is gradually—I would say rapidly—coming to the stage, and the war has helped along that stage, when he is being recognized by the manner in which he does a good job of work and therefore is worth a position in society, and that is far more valuable than any number of associations getting together and defining it. That is the conclusion we have come to in our country and I feel it is very much the same throughout the Commonwealth.

I am hoping that all these subjects will be discussed at our conference in London this summer. Naturally there are many other possibilities of subjects other than those I have mentioned, but whatever we do we must be quite sure that in that conference we do cement the friendship among all engineers which exists at present between engineers in my country and engineers in this great Dominion.

Greetings

We still remember, Ladies and Gentlemen, the very noble gesture that your Institute made early in the war when it invited our children to come into your homes. We can never forget that gesture. You brought a great deal of thought over the ocean toward your own Institute, to think that you, with your own cares and difficulties, were willing to take our children and look after them as you did.

Not only that, but during the fall of France there is no doubt about it that the feeling we had in the Mother Country that the Dominions were behind us was a tremendous factor in maintaining the morale of our country. If we had not felt that the Dominions were there to strengthen and support us we would have gone down feeling that we were completely finished because otherwise we were all alone.

Mr. President, a few days ago I crossed the Atlantic in company with some 10,000 of your returning lads and lassies from their great enterprise over the water, an enterprise, an achievement unique in history. These men and women left their homes, gave up their youth, risked their lives to vindicate their belief in human right and freedom which in your country and ours we hold sacred. They sacrificed their youth to overthrow the greatest tyranny in history and they won.

I speak, I am sure, to some who have

lost a son or a brother and I do so whose only son will never return, but with you I look for brighter days to come. During the trip on that great ship the *Queen Elizabeth,* I saw a symbol of hope, a symbol of certainty that Canada and Great Britain will stand shoulder to shoulder to preserve the sanctities of life.

To The Engineering Institute of Canada I bring the greetings of the civil, mechanical and electrical Engineers of Great Britain whom I am privileged to represent.

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